

EVERYDAY

DECEMBER 1990

ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

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New Teach-In Series **DESIGN YOUR OWN CIRCUITS**

**EIGHT CHANNEL MICROCOMPUTER
CONTROLLED LIGHT SEQUENCER**

VERSATILE BENCH POWER SUPPLY

FREE INSIDE!
MAGENTA ELECTRONICS
1991 CATALOGUE

PLUS INDEX FOR 1990

ISSN 0262-3617



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The No.1 Magazine for Electronic & Computer Projects



ONE POUND PACKS



All packs are £1 each. Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

- BD2 5 13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off.
- BD9 2 6V 1A mains transformers upright mounting with fixing clamps.
- BD13 12 30 watt reed switches, it's surprising what you can make with these—burglar alarms, secret switches, relay, etc., etc.
- BD22 2 25 watt loudspeaker two unit crossovers.
- BD30 2 Nicad constant current chargers adapt to charge almost any nicad battery.
- BD32 2 Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch.
- BD42 5 13A rocker switch three tags so on/off, or change over with centre off.
- BD45 1 24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day, original cost £40 each.
- BD49 5 Neon valves, with series resistor, these make good night lights.
- BD56 1 Mini unisector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole.
- BD67 1 Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks.
- BD103A 1 6V 750mA power supply, nicely cased with mains input and 6V output leads.
- BD120 2 Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc.
- BD132 2 Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch.
- BD134 10 Motors for model aeroplanes, spin to start so needs no switch.
- BD137 1 6 1/2 inch 4 ohm speaker 10W rating.
- BD139 6 Microphone inserts—magnetic 400 ohm also act as speakers.
- BD148 4 Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets.
- BD149 6 Safety cover for 13A sockets—prevent those inquisitive little fingers getting nasty shocks.
- BD180 6 Neon indicators in panel mounting holders with lens.
- BD193 6 5 amp 3 pin flush mounting sockets make a low cost disco panel.
- BD199 1 Mains solenoid, very powerful, has 1in pull or could push if modified.
- BD201 8 Keyboard switches—made for computers but have many other applications.
- BD211 1 Electric clock, mains operated, put this in a box and you need never be late.
- BD221 1 12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK.
- BD252 1 Panostat, controls output of boiling ring from simmer up boil.
- BD259 50 Leads with push-on 1/4in tags—a must for hook-ups—mains connections etc.
- BD263 2 Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattern.
- BD268 1 Mini 1 watt amp for record player. Will also change speed of record player motor.
- BD305 1 Tubular dynamic mic with optional table rest.
- BD653 2 Miniature driver transformers. Ref. LT44. 20k to 1k centre tapped.
- BD548 2 3.5V relays each with 2 pairs changeover contacts.
- BD667 2 4.7 10k non-polarised black capacitors, pcb mounting.

There are over 1,000 items in our Catalogue. If you want a complete copy please request this when ordering.

METAL PROJECT BOX Ideal for battery charger, power supply etc. Sprayed grey size 8" x 4" x 4 1/2". Louvered for ventilation. Price £3.00. Ref. 3P75.

FLOPPY DISCS 5 1/4" pack of 10 £5.00. Ref. 168. 3 1/2" pack of 15 £10.00. Ref. 10P88.

PERSONAL STEREOS Again customer returns but complete and with stereo head phones. A bargain at only £3.00 each. Our ref 3P83.

MICROWAVE CONTROL PANEL Mains operated, with touch switches. This unit has a 4 digit display with a built in clock and 2 relay outputs—one for power and one for pulsed power level. Could be used for all sorts of timer control applications. Only £6.00. Our ref 6P18.

EQUIPMENT WALL MOUNT Multi adjustable metal bracket ideal for speakers, lights, etc. 2 for £5.00. Our ref 5P152.

NEW MAINS MOTORS 25 watt 3000 rpm made by Framco. Approx 6" x 3" x 4". Priced at only £4.00 each. Our ref 4P54.

SHADED POLE MOTORS Approx 3" square. Available in 24V and 240V AC. Both with threaded output shaft and 2 fixing bolts. Price £2.00 each. 24V Ref 2P65, 240V Ref 2P66.

SUB-MIN TOGGLE SWITCH Body size 8mm x 4mm x 7mm SBDT with chrome dolly fixing nuts. 3 for £1. Order ref BD649.

COPPER CLAD PANEL for making PCB. Size approx 12in long x 8 1/2in wide. Double-sided on fibreglass middle which is quite thick (about 1 1/16in) so this would support quite heavy components and could even form a chassis to hold a mains transformer, etc. Price £1 each. Our ref BD683.

POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, workshop etc. Makes you feel better and work harder—a complete mains operated kit, case included. £18. Our ref 18P2.

2KV 500 WATT MAINS TRANSFORMERS. Suitable for high voltage experiments or as a spare for a microwave oven etc. £10.00. Ref. 10P93.

REAL POWER AMPLIFIER for your car, it has 150 watts output. Frequency response 20Hz to 20KHz and signal to noise ratio better than 60dB. Has built in short circuit protection and adjustable input level to suit your existing car stereo, so needs no pre-amp. Works into speakers ref. 30P7 described below. A real bargain at only £57.00. Order ref: 57P1.

REAL POWER CAR SPEAKERS. Stereo pair output 100W each. 40hm impedance and consisting of 6 1/2" woofer, 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00. Order ref: 30P7.

VIDEO TAPES These are three hour tapes of superior quality, made under licence from the famous JVC company. Offered at only £3 each. Our ref 3P63. Or 5 for £11. Our ref 11P3. Or for the really big user 10 for £20. Our ref 20P20.



ELECTRONIC SPACESHIP.

Sound and impact controlled, responds to claps and shouts and reverses when it hits anything. Kit with really detailed instructions. Ideal present for budding young electrician. A youngster should be able to assemble but you may have to help with the soldering of the components on the pcb. Complete kit £10. Our ref. 10P81

COMPUTER KEYBOARDS Brand new, uncased, £3.00 each. ref 3P89.

12" HIGH RESOLUTION MONITOR. Amber screen, beautifully cased for free standing, needs only 12V 1.5 amp supply. TTL input separate syncs. Brand new in makers' cartons. Price £22.00. Order ref. 22P2.

SINCLAIR C5 WHEELS

Including inner tubes and tyres. 13" and 16" diameter spoked poly carbonate wheels. Finished in black. Only £6.00 each. 13" Ref 6P10, 16" Ref 6P11

COMPOSITE VIDEO KITS These convert composite video into separate H sync, V sync and video. Price £8.00. Our ref 8P39.

LINEAR POWER SUPPLY. Brand new +5V 3A, +/−12V 1A. Complete with circuit diagram. Short circuit protected. Our price £12.00. Ref. 12P21.

3 1/2in FLOPPY DRIVES We still have two models in stock: Single sided, 80 track, by Chinton. This is in the manufacturers metal case with leads and IDC connectors. Price £40, reference 40P1. Also a double sided, 80 track, by NEC. This is uncased. Price £60.00, reference 60P2. Both are brand new.

10 MEMORY PUSHBUTTON TELEPHONES These are customer returns and "sold as seen". They are complete and may need slight attention. Price £6.00. Ref. 6P16 or 2 for £10.00. Ref. 10P77. BT approved.

INDUCTIVE PROXIMITY SWITCHES These will detect ferrous or nonferrous metals at approx. 10mm and are 10-36V operation. Ideal for alarms position sensors, etc. RS price is £64.00 each! Ours £12.00. Ref. 12P19.

BOSCHERT SWITCHED MODE POWER SUPPLIES −5V at 15A, −12V at 3A, −12V at 2A +24V at 2A, 220V or 110V input. Brand new and guaranteed. Retail price is £180! Ours £20. Ref. 20P30.

TV SOUND DECODER. Nicely cased, mains powered with 8 channels. Will drive a small speaker directly or could be fed into HI FI system etc. £12.00 each. Ref. 12P22.

PC POWER SUPPLIES Brand new with built in fan and power switch on the back −5, −5, −12, −12V 150 watt made by AZTEC £25.00 each. Ref. 25P18.

VERY POWERFUL 12 VOLT MOTORS. 1/2d Horsepower. Made to drive the Sinclair C5 electric car but adaptable to power a go-kart, a mower, a rail car, model railway, etc. Brand new. Price £20. Our ref 20P22.

AS ABOVE with gearbox £40. Ref 40P8.

PHILIPS LASER

This is helium-neon and has a power rating of 2mW. Completely safe as long as you do not look directly into the beam when eye damage could result. Brand new, full spec. £35. Our ref. 35P1. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15.

PANEL METERS 270 deg movement. New, £3.00 each. Our ref 3P87.

SURFACE MOUNT KIT Makes a super high gain snoping amplifier on a PCB less than an inch square! £7.00. Our ref 7P15.

CB CONVERTERS Converts a car radio into an AM CB receiver. £4.00. Our ref 4P48.

GEIGER COUNTER KIT Includes PCB, tube, loudspeaker, and all components to build a 9v battery operated geiger counter. Only £39. Our ref 39P1.

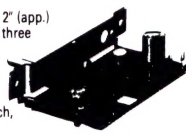
12V TO 220V INVERTER KIT This kit will convert 12v DC to 220v AC. It will supply up to 130 watts by using a larger transformer. As supplied it will handle about 15 watts. Price is £12. Our ref 12P17.

5 1/4" 360K DISC DRIVES. Brand new HALF HEIGHT disc drives made by Mitsubishi. Limited quantity available at £35.00. Ref. 35P5.

HIGH RESOLUTION MONITOR 9in black and white, used Philips tube M24/360W. Made up in a lacquered frame and has open sides. Made for use with OPD computer but suitable for most others. Brand new. £20. Our ref 20P26.

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape (4 1/2in x 4 1/2in x 1 3/4in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. £8 each. Our ref 8P26.

MINI MONO AMP on p.c.b. size 4" x 2" (app.) Fitted Volume control. The amplifier has three transistors and we estimate the output to be 2W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or 13 for £12.00.



BULL ELECTRICAL

Dept. EE 250 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QT.



MAIL ORDER TERMS: Cash, PO or cheque with order. Monthly account orders accepted from schools and public companies. Please add £2.50 postage to orders. Minimum order £5. Phone (0273) 203500. Fax No. (0273) 23077.

POPULAR ITEMS — MANY NEW THIS MONTH

MAINS FANS Snail type construction. Approx. 5" x 4" mounted on a metal plate for easy fixing. New. £5.00 each. Our ref 5P166.

MICROWAVE TURNTABLE MOTOR Complete with weight sensing electronics that would have varied the cooking time. Ideal for window displays, etc. Only £5.00. Our ref 5P165.

PC STYLE CASES 18" x 18" x 6" Complete with fan and grill illuminated power switch and IEC filtered power input plug. Priced at only £15.00. Ref. 15P38.

VERO EASIWIPE PROTOTYPING SYSTEM. Ideal for designing projects on etc. Complete with tools, wire and reusable board. Our price £6.00. Ref 6P33.

MAINS AXIAL FANS. Brand new 5" diameter powerful silent fans with shaped pole motors. Yours for £3.00. Ref 3P112.

AA CELLS Probably the most popular of the rechargeable NICAD types. 4 for £4.00. Our ref. 4P44.

20 WATT 4 OHM SPEAKER With built in tweeter. Really well made unit which has the power and the quality for hifi 6 1/2" dia. Price £5.00. Our ref. 5P155 or 10 for £40.00. Ref. 40P7.

MINI RADIO MODULE Only 2in square with ferrite aerial and solid dia. tuner with own knob. It is superhet and operates from a PP3 battery and would drive a crystal headphone. Price £1.00. Our ref. BD716.

BULGIN MAINS PLUG AND SOCKET The old and faithful 3 pin with screw terminals. The plug is panel mounted and the socket is cable mounted. 2 pairs for £1.00 or 4 plugs or 4 sockets for £1.00. Our ref. BD715, BD715P, or BD715S.

MICROPHONE Low cost hand held dynamic microphone with on/off switch in handle. Lead terminates in 1.5 mm and 1.25 mm plug. Only £1.00. Ref. BD711.

MOSFETS FOR POWER AMPLIFIERS AND HIGH CURRENT DEVICES 140V 100 watt pair made by Hitachi. Ref. 2SJ99 and its complement 2SK343. Only £4.00 a pair. Our ref. 4P51.

TIME AND TEMPERATURE LCD MODULE A 12 hour clock a Celsius and Fahrenheit thermometer a too hot alarm and a too cold alarm. Approx 50x20mm with 12.7mm digits. Requires 1AA battery and a few switches. Comes with full data and diagram. Price £9.00. Our ref. 9P5.

REMOTE TEMPERATURE PROBE FOR ABOVE. £3.00. Our ref. 3P60.

PAPST fan 80 x 80mm 230V. Our ref 9P7. Price £9.

PAPST fan 120 x 120mm 230V. Our ref 6P6. Price £6.

600 WATT AIR OR LIQUID MAINS HEATER Small coil heater made for heating air or liquids. Will not corrode, lasts for years. Coil size 3" x 2" mounted on a metal plate for easy fixing. 4" dia. Price £3.00. Ref. 3P78 or 4 for £10.00. Our ref. 10P76.

EX-EQUIPMENT POWER SUPPLIES Various makes and specs, ideal bench supply. Only £8.00. Our ref. 8P36.

ACORN DATA RECORDER Made for the Electron or BBC computer but suitable for others. Includes mains adaptor, leads and book. £12.00. Ref. 12P15.

SOLDER

22 SWG 60/40 resin coated solder, %KG reel, top quality £4.00. Ref 4P70

NEW PIR SENSORS Infra red movement sensors will switch up to 1000W mains. UK made, 12 months manufacturers warranty, 15-20m range with a 0-10mm timer, adjustable wall bracket. Our ref 25P16. Price £25.

GEARBOX KITS Ideal for models, etc. Contains 18 gears (2 of each size), 4 x 50mm axles and a powerful adjustable speed motor. 9-12V operation. All the gears, etc. are 2mm push fit. £3.00 for the complete kit. Ref. 3P93.

MINI HIFI SPEAKERS Made for televisions, etc. Two sizes available. 70mm x 57mm 3W 8 ohm, 2 for £3.00. Ref 3P99. 127mm x 57mm 5W 8 ohm, 2 for £3.00. Ref. 3P100.

TELEPHONE EXTENSION LEAD 5m phone extension lead with plug on one end, socket on the other. White. Price £3.00. Our ref. 3P70 or 10 leads for only £19.00! Ref. 19P2.

LCD DISPLAY 4 1/2" digits supplied with connection data £3.00. Ref. 3P77 or 5 for £10. Ref. 10P78.

CROSS OVER NETWORK 8 Ohm 3 way for tweeter midrange and woofer nicely cased with connections marked. Only £2.00. Our ref. 2P255 or 10 for £15.00. Ref. 15P32.

BASE STATION MICROPHONE Top quality uni-directional electret condenser mic 600r impedance sensitivity 16-18KHz — 68db built in chime complete with mic stand bracket. £15.00. Ref. 15P28.

MICROPHONE STAND Very heavy chromed mic stand, magnetic base 4" high. £3.00 if ordered with above mic. Our ref. 3P80.

SOLAR POWERED NICAD CHARGER 4 Nicad AA battery charger. Charges 4 batteries in 8 hours. Price £6.00. Our ref. 6P3.

YUASHA SEALED LEAD AC BATTERIES. 6V 10AH only £9.00 each or 2 for £15.00. Ref. 15P37.

STC SWITCHED MODE POWER SUPPLY. 220V or 110V operation giving 5V at 2A +24V at 0.25A −12V at 0.15A and −90V at 0.4A £12.00 each. Ref. 12P27.

SOLDERING IRON STAND Price £3.00. Our ref. 3P66.

INCAR GRAPHIC EQUALIZER/BOOSTER Simline 7 band with built in 30 watts per channel amplifier. 12V operation, twin 5 LED power indicators, 20-21KHz with front and rear fader plus headphone output! Brand new and guaranteed. Only £25.00. Ref. 25P14.

MODEMS Dial up brand new units. Made by GEC. No data available, but good value at £18.00. Ref. 18P6.

CAR IONIZER KIT Improve the air in your car, clears smoke and helps prevent fatigue. Case req. Price £12.00. Our ref. 12P8.

NEW FM BUG KIT New design with PCB embedded coil 9v operation. Priced at £5.00. Our ref. 5P158.

NEW PANEL METERS 50uA movement with three different scales that are brought into view with a lever. Price only £3.00. Ref. 3P81.

ELECTRONIC SPEED CONTROL KIT Suitable for controlling our powerful 12v motors. Price £17.00. Ref. 17P3 (heatsink required).

ELECTRONIC TICKET MACHINES. These units contain a magnetic card reader, two matrix printers, motors, sensors and loads of electronic components etc. Very good value at £12.00. Ref. 12P28 (12" x 7" x 7")

JOYSTICKS. Brand new, can be adapted for most machines by changing the connector. Complete with 2 fire buttons and suction feet 2 for £5.00. Ref. 5P174.

FIVE POUND MYSTERY PACKS. We have decided to reintroduce our mystery packs once again. After a gap of 4 years we have amassed quite a lot of stock! For £5.00 you will receive a selection of goods containing at least £10.00 worth of goods at our normal low prices. Ref. 5P175.

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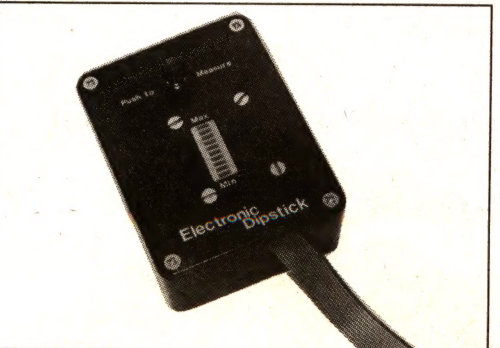
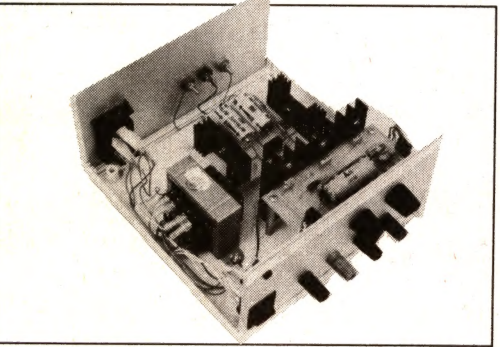
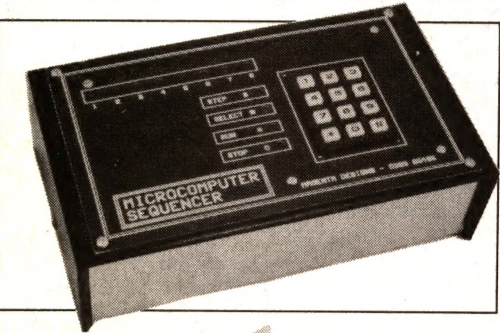
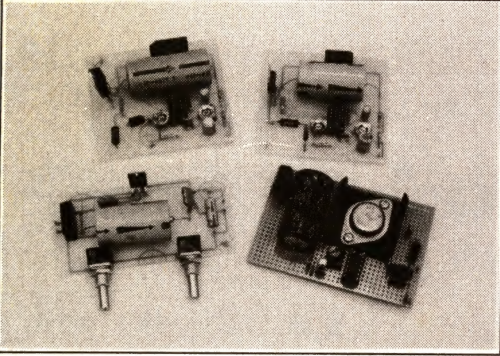
ABC

VOL. 19 No. 12 DECEMBER 1990

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ISBN 0262 3617

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COMMENT ... POPULAR FEATURES ...



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Versatile lighting unit with over 100 different programs

ELECTRONIC DIPSTICK by Chris Bowes

780

A Pocket Money Project for remote liquid level sensing

COLOUR-CHANGING CHRISTMAS LIGHTS

by Mark Daniels

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A colourful alternative to the usual festive decorations

VERSATILE BENCH POWER SUPPLY by Mike Tooley

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by T. R. de Vaux Balbirnie

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Magenta Electronics Ltd 1990-1991 catalogue, between pages 800 and 801

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Our January '91 Issue will be published on Friday, 7 December 1990. See page 813 for details.

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ELEMENTS £4.10 STANDS £3.24

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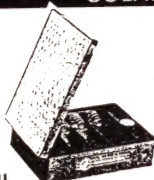
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AAA	1+	£1.50
AA	95p	£1.30
C	£1.95	£1.80
D	£2.00	£1.85
PP3	£3.90	£3.75

VIDEO HEAD TESTER



A video head tester for determining whether a video head is in good condition by detecting the wear state and displaying it on a meter. Complete with carrying case and leads.
SPECIAL PRICE £39.50

SOLAR PRODUCTS



Solar Cell
0.5V 700mA. Complete in plastic frame, connect in series for higher voltage.
Price: £3.99

Battery charger
Charges up to 4 x AA Ni-cads in 10-14 hours (2-3 hours per battery).
Price: £8.50



Solar Turntable
Ideal for shop window, house plants etc. Simply place in sunlight. Will turn up to 30lb load.
Price: £13.50

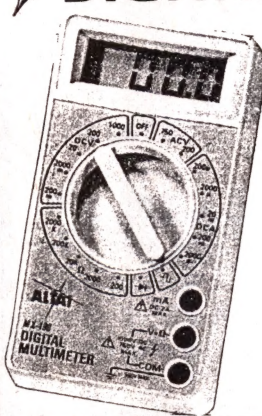
Educational Kit
A must for beginners. Contains instruction book, DC motor, solar panel, wire clips, spinner disc, etc.
Price £6.99

21-PIECE TOOL SET

21 pc precision tool set in plastic moulded clear case with sliding lid. Set contains: 6 x flat blade screwdrivers, 0.9-3.5mm; 2 x cross head screwdrivers No0 & No 1; 3 hex key wrenches 1.5, 2.0, 2.5mm; 5 nut drivers, 3.0, 3.5, 4.0, 4.5, 5.0mm; 5 spanners, 4.0, 4.5, 5.0, 5.5, 6mm and a tommy bar. TOOL/21PC
£6.50



December Special Offer



10MΩ MULTIMETER

- ★ 19 ranges
- ★ 3½ digit 12mm LCD display
- ★ Signal injector function
- ★ Diode test
- ★ Fuse protection
- ★ Automatic polarity and zero
- ★ Test leads with 4mm plugs

Fantastic Offer

AC volts.....0-200-750Vac ±1.2%
DC volts.....0-200m-2-20-200-1000Vdc ±0.8%
DC current.....0-200μ-2m-20m-200m-2A dc ±1.0%
Resistance.....0-200-2k-20k-200k-2MΩ ±0.8%
Signal injector.....50Hz square wave
5V peak to peak
126 x 70 x 24mm

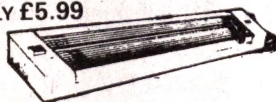
Dims.....
Battery and instruction manual included

ONLY £15.99

Y122AJ (MX190) **NORMALLY £39.50**

12V TWIN FLUORESCENT LAMP 12" DOUBLE TUBES

ONLY £5.99



DIMENSIONS: 368 X 67 X 43MM

HOME ALARM PACKAGE

- Includes:
- ★ Optima Alarm Control Panel
 - ★ External Red Bell Box
 - ★ 2 x 1 Internal Passive I.R.
 - ★ 2 x Door Contacts
 - ★ Siren for bell box
 - ★ 100 mtrs. cable and clips
 - ★ Full fitting instructions
- BACK-UP LEAD ACID BATTERY**
12V 1.9Ah
£14.00
LEAD ACID CHARGER
£19.99

ONLY £127.50

CLOSED CIRCUIT TELEVISION SYSTEM



Complete price £175 PLUS £10 CARR

FM TRANSMITTER

Very High Quality "MINI-BUG" Ideal for baby alarms etc!! reception on any FM radio. Frequency: 105-109MHz FM. Power: PP3 9V battery (not included). Dimensions: 4.25" x 2.25" x 0.76" Code S0.004

£9.99

TDK CASSETTES

AD 90, used once. Bulk erased, good as new, fully guaranteed.

£7.50 for 10
£60.00 for 100



QUARTZ HALOGEN SPOT LIGHT
£5.75

EPROM SPECIAL

27C256-25 (BRAND NEW)
£3 ea 10 + £2.50 ea

VELLEMAN KITS

Send large S.A.E. now for our 1991 Full Colour Kit Catalogue

SOLDER 18 & 22 SWG -500gm REEL

	1+	10+
18swg	£4.95	£4.70
22 swg	£4.99	£4.75

Remember: Our prices INCLUDE VAT!

HEATSHRINK PACK

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These need no introduction, brand new, complete with cartridge and stylus. Also, complete with turntable belt. 12V 0.06A motor fitted. Simply construct your own plinth. Absolute bargain.
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Very handy, illuminated magnifier with mains lens X2 and pull out lens X8 magnification. Main lens can be illuminated for map or book reading. Uses 2 x AA batteries (Yes, supplied). Overall length, extended 6" (150mm).
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Hewlett Packard HP1631D Complete with Disc Drive (HP9122D), Printer (HP225A). Various probes, etc. Approx. 4 years old. List price over £14,000! **OUR PRICE £1,500**

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For disco consoles, Hi-Fi equipment, CB rigs, etc. where extra illumination is essential, 12V lamp in enclosed head with switch. Flexible chrome gooseneck on mounting plate with screw holes. Flying leads for connection to external 12Vdc supply. Length 300mm. Lamp 12V dc 5W tubular filament. L100
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Dimensions.....150 x 150 x 120mm
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MICROPHONE MIXER

4-channel mono microphone mixer. Inputs via 6.35mm mono sockets with individual volume controls. Output via 6.35mm mono socket with master volume control. ON/OFF switch and LED ON indicator. Tough steel case. Powered by 9V battery. Complete with 1.5m patch lead.
Input impedance.....600 ohms
Output Impedance.....1.2Kohms
Output level.....90mV (for 5mV input)
Power.....9V d.c. (PP3) battery
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ORDER CODE MIC/MIXER £19.50

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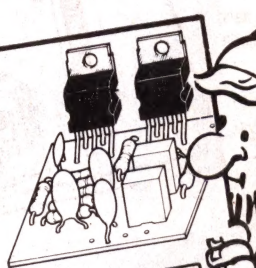
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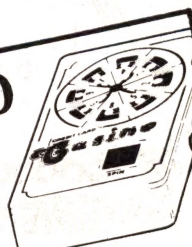


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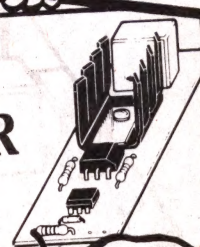
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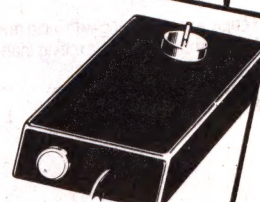
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Please tick the boxes for the kits you would like and return the entire list to us. All prices include VAT, but please don't forget to add £1.20 for postage and packing. No orders accepted at these prices after 20th December 1990.

Please debit my ACCESS card no. I enclose cheque for £.....

Name

Address

Welcome to the 1990 Christmas list! Whether you intend to make somebody an original Christmas present or to treat yourself to a project for the holidays, there's just so much to choose from. To be sure of getting your products for Christmas, please allow enough time for postal delays in both directions and for our staff (who are very busy at this time of year, bless 'em) to pack your order. If you have an ACCESS card, you can speed things up by phoning in your order on 0600 3715, and we'll post your projects the very same day.

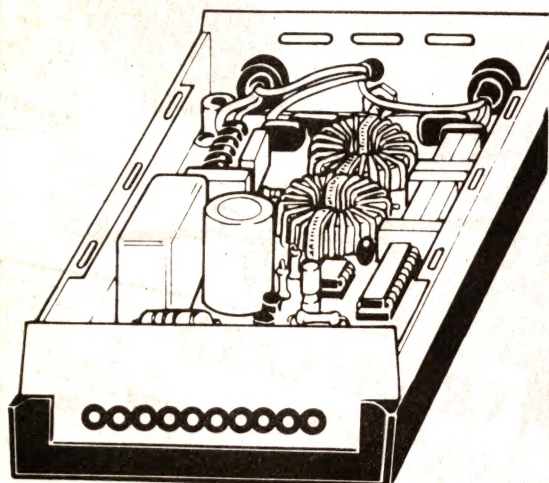
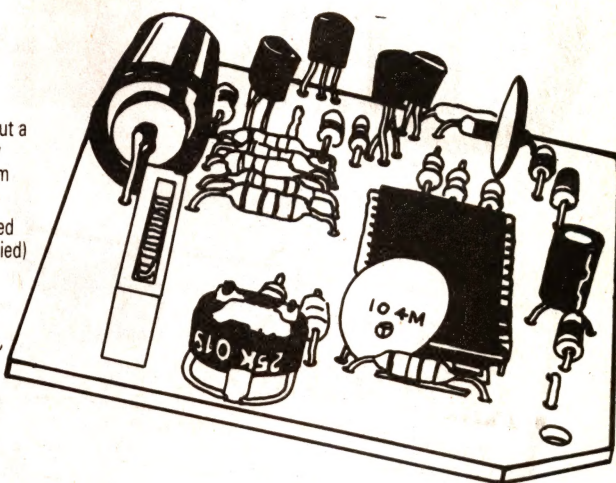
SOUND FX COMPUTER ▷

This super project will make the most outrageously realistic sounds you've ever heard! How about a motor rally complete with revving engines and gear changes? Or a ship hooting its mournful way through the fog? Or a fly so realistic it'll have you running for the swat! Sirens, helicopters, steam trains, aliens—you name it, it's in there. In one mode you can even play it like a synthesizer!

The computer is ready built and programmed, and has its own audio amplifier built in. All you need to do is to connect up the speaker (supplied), wire together the 13 programming switches (supplied) and you're ready for action! What a Christmas present!

~~£14.72~~

£10.95



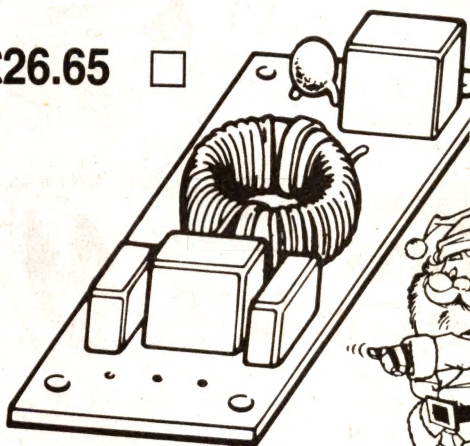
◁ POWER CONDITIONER

You don't have to be a hi-fi nut to notice the huge improvement in sound quality when you run your music system from a clean mains supply. How do you describe the difference? It's as if all this time your favourite artists have been playing and singing inside a wardrobe... and someone has just opened the door and let them out. You could spend 20 times as much on special cables, plugs, mats and stuff without achieving a tenth of the difference. But don't take my word for it. Try it for yourself.

The sophisticated circuitry of the Power Conditioner begins with a bank of six VDRs to eliminate impulsive spikes. Then comes a massive filter with thirteen capacitors and two current-balanced inductors to smooth away every trace of noise and interference. A ten LED logarithmic display flicks up and down as each spike is eliminated, and gives a second by second account of the interference removed. Maximum load 1.5kW.

~~£34.27~~

£26.65



MAINS CONDITIONER ▷

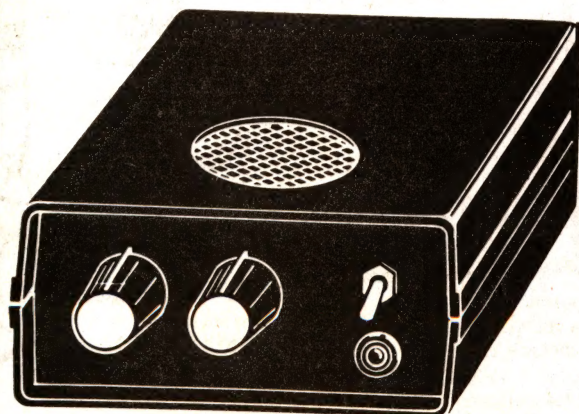
If the budget won't stretch to the full Power Conditioner, its smaller brother the Mains Conditioner will give you a taste for the clear sounds. Just the thing for computer supplies too—it catches the spikes before they can do any harm.

~~£6.21~~

£5.65



Rugged plastic case £2.07



◁ THE DREAM MACHINE

What a project this is! The hypnotic powers of pink noise are not to be underestimated.

Legend has it that a New York dentist used to pull patients' teeth with only the gentle whoosh of pink sound to soothe them. No anaesthetic! Not something I'd care to try myself, but having experienced the effects of the Dream Machine I can well believe it.

The main function of the project is to give a truly refreshing sleep. One that leaves you feeling alert and ready for anything, not half dead until the third cup of coffee. For babies and young children it's just the thing. They drift into sleep quickly and are far less likely to wake in the middle of the night.

As for me, I enjoy experimenting with lucid dreams—ones where I'm completely in control of the action. The night time can be more exciting than the day!

~~£22.77~~

£16.95



SILVER SOLUTION

We stock this for plating the electrodes on our Brainwave Monitor, but it's such fascinating stuff I just had to add it to the Christmas list. Just run a little onto any metal surface—coins, ornaments, PCB tracks—and a silver coating appears. This is real silver, bonded just as thoroughly to the metal as if it has been silver plated. Amazing stuff! Have a bottle for yourself and a few to give away as presents.

Silver solution £4.37



Three bottles of Silver Solution £11.95



We deliver from stock - The fastest way to order is a fax !

ULTRASONIC CAR ALARM

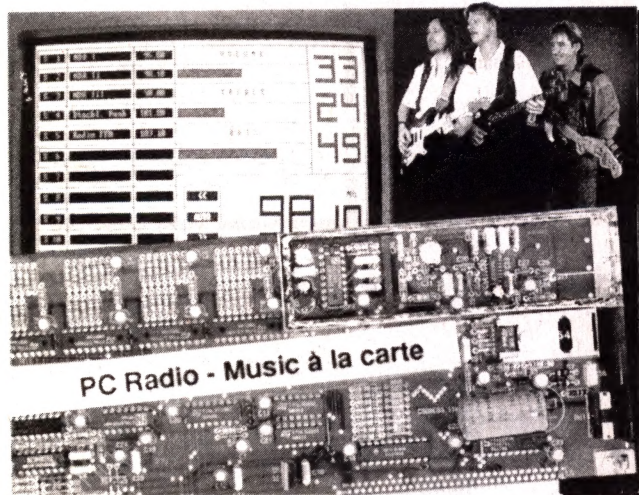


This system is specially designed to protect your car and its contents against potential thieves. Low current consumption and high noise immunity are just two of its distinguishing features.

Complete kit including case
44.3678KL £ 30.40

In addition the system has a voltage sensing device i.e. the alarm is also triggered if appliances are switched on by an unauthorised person (e.g. the interior lighting when the door is opened).

PC Radio (Elektronics February 1990)



DIGITAL PROFESSIONAL ECHO 1000

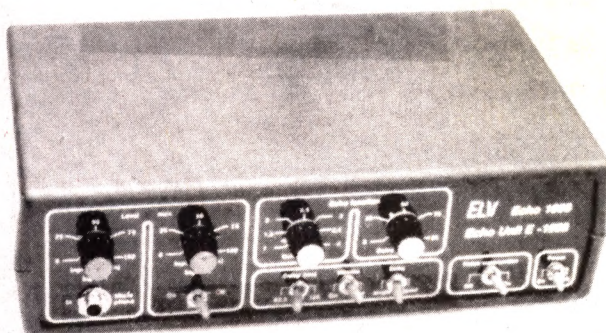
(Elektronics June 89)

This low cost echo unit is certain to impress music lovers - amateur and professional - everywhere. Excellent specification and top performance make the EU 1000 a winner and despite meeting professional requirements the unit will not make too big a hole in your pocket. Working on the delta modulation prin-

ciple on a digital base, delay times up to one second are possible at full bandwidth and large signal to noise ratio.

Complete kit
44.2558KL £ 99.50

Ready assembled module
44.255F £ 134.50



Specification

Input sensitivity:
Input 1 : 2 mV
Input 2 : 200 mV

Delay Time:
variable from 60 ms to 1 s

Bandwidth :
100 Hz to 12 kHz

Additional features:

- inputs mixable
- single and multiple echo
- adjustable delay level
- switchable vibrator
- switch-controlled noise suppression

This FM radio consists of an insertion card for IBM PC-XTs, ATs and compatibles and is available as a kit or a ready-built and aligned unit. The radio has an on-board AF power amplifier for driving a loudspeaker or a headphone set, and is powered by the computer. A menu-driven program is supplied to control the radio settings.

Complete kit
44.5448KL £ 82.75

Ready assembled module
44.544F £ 137.30

VM 1000 Video-Modulator

(Elektronics March 90)

Many inexpensive or older TV sets lack a SCART or other composite video input, and can only be connected to a video recorder or other equipment via an RF modulator. The modulator operates at a UHF TV channel between 30 and 40. Use is made of a single-chip RF modulator that couples low cost to excellent sound and picture quality.

Complete kit
44.5468KL £ 36.90

Ordering and payment:

- all prices excluding V.A.T. (french customers add 18.6%T.V.A.)
- send Euro-cheque, Bank Draft or Visa card number with order. Please add £ 3.00 for p & p (up to 2 kg total weight)
- postage charged at cost at higher weight Air/Surface -
- we deliver worldwide except USA and Canada
- dealer inquiries welcome

RFK 7000 RGB-CVBS Converter

(Elektronics October 89)

Nearly all computers supply as an output signal for colour monitors RGB signals. With the help of the RFK 7000 it is possible to record this signals with a videorecorder or to give them onto a colour TV (This is only possible, if the

computer delivers a vertical sync. of 50 Hz and a horizontal sync. of 15.625 Hz).

The voltage supply is gained from a 12V/300mA-DC voltage mains adaptor.

Complete kit
44.5258KL £ 66.50

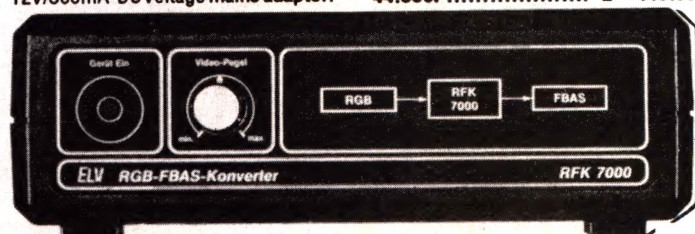
Ready assembled module
44.525F £ 119.50

FRK 7000 CVBS-RGB Converter

With the help of the FRK 7000 e.g. it is possible to use a cheap colour monitor with RGB input on a video recorder. The voltage supply is gained from a 12V/300mA-DC voltage mains adaptor.

Complete kit
44.5098KL £ 66.50

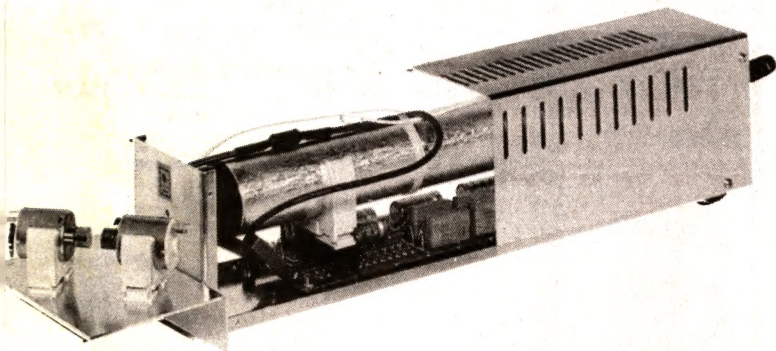
Ready assembled module
44.509F £ 119.50



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LPS 8000 / LC 7000 Low Cost Show Laser

(Electronics The Maplin Magazine Dec 88 + Feb-Mar 90)



An almost infinite number of circular patterns can be projected onto a wall or ceiling with this super laser show equipment.

The complete project includes a laser tube and accompanying power supply, housed in a metal case, and a laser controller, LC 7000. The laser controller drives the accompanying deflection unit, fixed onto the laser power supply case, which produces the numerous configurations.

Naturally the laser tube, together with the power supply, can produce beams without the laser controller and the controller can be used with other, similar lasers.

LPS 8000 Laser Power Supply, complete kit

Version 240 Volts AC	
44.428BKL220	£ 86.90
Version 220 Volts AC	
44.428BKL240	£ 86.90

LC 7000 Laser Controller, complete kit

Version 12 Volts DC	
44.427BKL	£ 60.80

H-N Laser Tube 2 mW

44.428LR	£ 60.80
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LPS 8000 Laser Power Supply, ready assembled module

Version 240 Volts AC	
44.428F240	£ 156.50
Version 220 Volts AC	
44.428F220	£ 156.50

LC 7000 Laser Controller, ready assembled module

Version 12 Volts DC	
44.427F	£ 104.30

Laser Motor-Mirror Set, complete kit

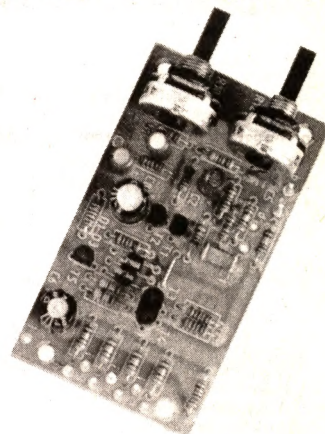
44.506M	£ 22.95
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VIDEO RECORDING AMPLIFIER

(Elektronics April 89)

Losses can easily occur when copying video tapes resulting in a distinct reduction in quality. By using this video recording amplifier, with no less than four (!) outputs, the modulation range is enlarged and the contrast range of the copy increases.

Two level controllers for edge definition (contour) and amplification (contrast range) allow individual and precise adaptation.



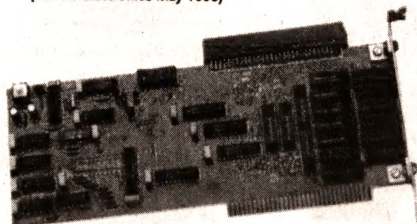
Complete Kit
(including Box, PCB and all parts)
44.324BKL

£ 14.75

IBM PC Service Card

(Elektronics May 1990)

This card was developed for assistance in the field of service, development and test. The card is used as a bus-extension to reach the measurement points very easy. It is also possible to change cards without having a "hanging computer".



Complete kit

44.517BKL	£ 77.95
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Ready assembled module

44.517F	£ 137.95
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TA 1000 Telephone Answering Unit

(Elektronics January 1990)

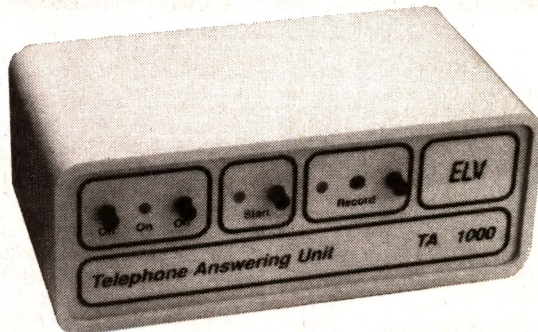
This automatical telephone answering unit uses a 256-kbit voice recording circuit to store and replay your spoken message of up to 15 seconds. Noteworthy features are that it is available as a complete kit, provides a battery back-up facility and does not require alignment. No provision is made, however, to record incoming calls.

Complete kit

44.433BKL	£ 45.65
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Ready assembled module

44.433F	£ 87.25
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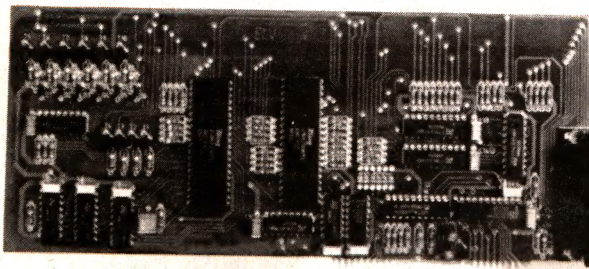


IC TESTER for IBM-PC-XT/AT

(Electronics The Maplin Magazine Jun-Jul 89 +

Elektronics December 89)

With the ELV IC tester logic function tests can be carried out on nearly all CMOS and TTL standard components, accommodated in DIL packages up to 20 pin. The tester is designed as an insertion card for IBM-PC-XT/AT and compatibles. A small ZIF test socket PCB is connected via a flat band cable. Over 500 standard components can be tested using the accompanying comprehensive test software.



Complete Kit including Textool socket, connectors, sockets, Flat band cable, PCB, Software

44.474BKL	£ 60.85
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Ready Assembled Module

44.474F	£ 113.00
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Software, single

44.474SW	£ 17.85
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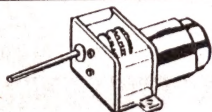
MICROCONTROLLER LIGHT SEQUENCER

EE DEC '90 KIT REF 838

A superb kit with pre-drilled painted and silk screen printed case for a really professional finish. This kit uses a microcontroller I.C. to generate 8-channel light sequences. Sequences are selected by keypad from over 100 stored in memory. Space for 10 user programmed sequences up to 16 steps long also available.
1000 watts per channel, zero volt switching, inductive load capability. Opto-isolated for total safety. Many other features. Complete kit includes case, PCBs, all components and hardware.
As published in EE Dec '90

£55.95

D.C. MOTOR GEARBOXES



Ideal for Robots and Buggies. A miniature plastic reduction gearbox coupled with a 1.5-4.5 Volt mini motor. Variable gearbox reduction ratios are obtained by fitting from 1 to 6 gearwheels (supplied). Two types available:

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MD35 1/4 PERMANENT MAGNET MOTOR — 48 steps per rev. **£12.70**

MD38 PERMANENT MAGNET MOTOR — 48 steps per rev. **£8.95**

HAMEG HM 203-7 OSCILLOSCOPE

New model just arrived. High quality reliable instrument made in W. Germany. Outstanding performance. Full two year parts and labour warranty.
20MHz-2 channels 1mV sensitivity
Easy to operate and high performance + £50.70 VAT
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EDUCATIONAL BOOKS & BOOK PROJECTS

ADVENTURES WITH ELECTRONICS

The classic Easy to Follow book suitable for all ages. Ideal for beginners. No soldering, uses an S-DEC breadboard. Gives clear instructions with lots of pictures. 16 projects — including three radios, siren, metronome, organ, intercom, timer, etc. Helps you learn about electronic components and how circuits work. Component pack includes an S-DEC breadboard and all the components for the series.

ADVENTURES WITH ELECTRONICS COMPONENT PACK (less book) **£5.25 £22.35**

FUN WITH ELECTRONICS

From the USBORNE Pocket Scientist series — An enjoyable introduction to electronics. Full of very clear full colour pictures accompanied by easy to follow text. Ideal for all beginners — children and adults. Only basic tools are needed. 64 full colour pages cover all aspects — soldering — fault finding — components (identification & how they work). Also full details of how to build 6 projects — burglar alarm, radio, game, etc. Requires soldering — 4 pages clearly show you how.

The components supplied in our pack allows all the projects to be built and kept. The book is available separately.

FUN WITH ELECTRONICS Book £2.95
COMPONENT PACK (less book) £17.55

30 SOLDERLESS BREADBOARD PROJECTS

A book of projects by R. A. Penfold covering a wide range of interests. All projects are built on a Verobloc breadboard. Full layout drawings and component identification diagrams enable the projects to be built by beginners. Each circuit can be dismantled and rebuilt several times using the same components. The component pack allows all projects in the book to be built one at a time. Projects covered include amplifiers, light actuated switches, timers, metronome, touch switch, sound activated switch, moisture detector, M.W. Radio, Fuzz unit, etc.

30 SOLDERLESS BREADBOARD PROJECTS Book 1 COMPONENT PACK **£2.95 £27.15**

ENJOYING ELECTRONICS

A more advanced book which introduces some arithmetic and calculations to electronic circuits. 48 chapters covering elements of electronics such as current, transistor switches, flip-flops, oscillators, charge, pulses, etc. An excellent follow-up to Teach-in or any other of our series. Extremely well explained by Owen Bishop who has written many excellent beginners' articles in numerous electronics magazines.

ENJOYING ELECTRONICS Book £3.60
COMPONENT PACK £14.31

Note — A simple multimeter is needed to fully follow this book. The M102 BZ is ideal. £13.98

A FIRST ELECTRONICS COURSE

A copiously illustrated book that explains the principles of electronics by relating them to everyday objects. At the end of each chapter a set of questions and word puzzles allow progress to be checked in an entertaining way. An S-DEC breadboard is used for this series — soldering is not required.

A FIRST ELECTRONIC COURSE BOOK £4.50
PACK £22.35

EVERYDAY ELECTRONICS KIT PROJECTS

ALL KITS HERE HAVE BEEN FEATURED IN EE. IF YOU DO NOT HAVE THE MAGAZINE WITH THE ORIGINAL ARTICLE, YOU WILL NEED TO ORDER THE REPRINT FOR 80p EXTRA. REPRINTS ALSO AVAILABLE SEPARATELY. KITS INCLUDE CASES, PCB'S, HARDWARE AND ALL COMPONENTS (UNLESS STATED OTHERWISE) CASES ARE NOT DRILLED, LABELS ARE NOT SUPPLIED.

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EE AUG 87

Covers 1.6-30 MHz in 3 bands using modern miniature coils. Audio output is via a built-in loudspeaker. Advanced design gives excellent stability, sensitivity and selectivity. Simple to build.

KIT REF 718

£29.66

MINI STROBE

EE MAY '86

A hand held stroboscope which uses 6 "ultra bright" LEDs as the light source. Designed to demonstrate the principles of stroboscope examination, the unit is also suitable for measuring the speed of moving shafts etc. The flash rate control covers 170-20,000 RPM in two ranges.

KIT REF 529

£15.50

ACOUSTIC PROBE

EE NOV '87

A very popular project which picks up vibrations by means of a contact probe and passes them on to a pair of headphones or an amplifier. Sounds from engines, watches and speech travelling through walls can be amplified and heard clearly. Useful for mechanics, instrument engineers and nosey parkers!

KIT REF 740

£19.58

4 CHANNEL LIGHT CHASER

EE Jan '90

A 1000W per channel chaser with zero volt switching, hard drive, inductive load capability, mic sound sensor and sophisticated 'beat' detector. Chase steps to music or auto when quiet. Variable speed and mic. sens. LED mimic on front panel. Switchable for 3 or 4 channels. P552 output. Ideal for rope lights, pin spots, disco and display lighting.

KIT REF 833

£31.45

EE EQUALISER

EE MAY '87

A mains powered ioniser with an output of negative ions that give a refreshing feeling to the surrounding atmosphere. Negligible current consumption and all-insulated construction ensure that the unit is safe and economical in use. Easy to build on a simple PCB.

KIT REF 707

£17.37

MUSICAL DOORBELL

EE JAN '86

This project uses a special I.C. pre-programmed with 25 tunes and 3 chimes. A Magenta design, the circuit is battery powered and only draws current whilst producing sounds. Two rotary switches select the tune required. Provision is made for three bell pushes, each of which sounds a different tune, so that three points of entry can be identified.

KIT REF 497

£20.95

EE TREASURE HUNTER

EE AUG '89

A sensitive pulse induction Metal Detector. Picks up coins and rings etc., up to 20cms deep. Low "ground effect". Can be used with search-head underwater. Easy to use and build, kit includes search-head, handle, case, PCB and all parts as shown.

KIT REF 815

Headphones

£41.95

£1.99

EPROM ERASER

EE OCT '88

Safe low-cost unit capable of erasing up to four EPROM's simultaneously in less than twenty minutes. Operates from a 12V supply. Safety interlock. Convenient and simple to build and use.

KIT REF 790

£27.90

LIGHT RIDERS

EE OCT '86

Three projects under one title - all simulations of the Knight Rider lights from the TV series. The three are a lapel badge using six LEDs, a larger LED unit with 16 LEDs and a mains version capable of driving six main lamps totalling over 500 watts.

KIT REF 559 CHASER LIGHT

£15.25

KIT REF 560 DISCO LIGHTS

£21.93

KIT REF 561 LAPEL BADGE

£11.40

SUPERHET BROADCAST RECEIVER

EE MAR '90

At last, an easy to build SUPERHET A.M. radio kit. Covers Long and medium Wave bands. built in loudspeaker with 1 watt output. Excellent sensitivity and selectivity provided by ceramic I.F. filter. Simple alignment and tuning without special equipment. Kit available less case, or with pre-cut and drilled transparent plastic panels and dial for a striking see-through effect.

KIT REF 835

£16.79

TK FOR KITS

GUARD DOG KIT



One of the best burglar deterrents is a guard dog and this kit provides the barking without the bite! Can be connected to a doorbell, pressure mat or any other intruder detector and produces random threatening barks. Includes mains supply and horn speaker.

XK125

£21.95

DISCO LIGHTING KITS



DL8000K 8-way sequencer kit with built-in opto-isolated sound to light input. Only requires a box and control knob to complete.**£39.95**

DL1000K 4-way chaser features bi-directional sequence and dimming 1kW per channel.**£23.95**

DLA/1 (for DZ1000K) Optional op-to input allowing audio beat/light response.**95p**

DL3000K 3-channel sound to light kit, zero voltage switching, automatic level control and built-in mic. 1kW per channel.**£19.55**

XK139 Uni-directional chaser. Zero switching and built-in audio input.**£12.95**

POWER STROBE KIT

Produces an intense light pulse at a variable frequency of 1 to 15Hz.

Includes high quality PCB, components, connectors, 5Ws strobe tube and assembly instructions. Supply: 240V ac. Size: 80x50x45.

XK124 STROBOSCOPE KIT. **£17.25**

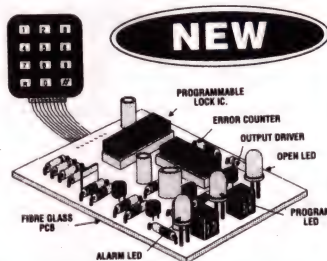


PROGRAMMABLE ELECTRONIC LOCK KIT

Keys could be a thing of the past with this new high security lock. Secure doors to sheds, garages, even your home or prevent the unauthorised use of computers, burglar alarms or cars. One 4-digit sequence will operate the lock while incorrect entries will sound an alarm. The number of incorrect entries allowed before the alarm is triggered is selected by you. Further entries will be ignored for a time also set by you. Only the correct sequence will open the lock and switch off the alarm. The sequence may easily be changed by entering a special number and code on the supplied keyboard. Kit includes; keyboard, alarm buzzer, high quality PCB and all electronic components. Supply 5-15V DC. Will drive our Latch Mechanism (701 150 @ £18.98) or relay directly.

XK131

£19.95



SIMPLE KITS FOR BEGINNERS

Especially aimed at the beginner. Have fun with your project even after you have built it and also learn a little from building it. These kits include high quality solder resist printed circuit boards, all electronic components (including speaker where used) and full construction instructions with circuit description.



SK1 DOOR CHIME plays a tune when activated by a pushbutton **£4.50**



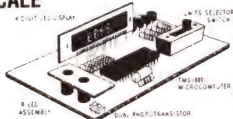
SK2 WHISTLE SWITCH switches a relay on and off in response to whistle command **£4.50**



SK3 SOUND GENERATOR produces FOUR different sounds, including police/ambulance/fire-engine siren and machine gun **£4.50**

XK118 TEN EXCITING PROJECTS FOR BEGINNERS this kit contains a solderless breadboard, components and a booklet with instructions to enable the absolute novice to build ten fascinating projects including a light operated switch, intercom, burglar alarm and electronic lock. Each project includes a circuit diagram, description of operation and an easy to follow layout diagram. A section component identification and function is included, enabling the beginner to build the circuits with confidence.**£17.25**

ELECTRONIC WEIGHING SCALE



Kit contains a single chip microprocessor. PCB, displays and all electronics to produce a digital LED readout of weight in Kgs or Sts/Lbs. A PCB link selects the scale-bathroom/two types of kitchen scales. A low cost digital ruler could also be made.

ES1

£8.25

VOICE RECORD/PLAYBACK KIT

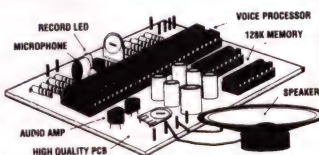
This simple to construct and even simpler to operate kit will record and playback short messages or tunes. It has many uses - seatbelt or light reminder in the car, welcome messages to visitors at home or at work, warning messages in factories and public places. In fact anywhere where a spoken message is announced and which needs to be changed from time to time. Also suitable for toys - why not convert your daughter's £8 doll to an £80 taking doll!!

Size 76 x 60 x 15mm

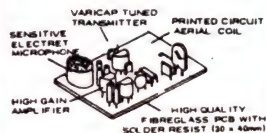
Message time 1-5 secs normal speed, 2-10 secs slow speed

XK129

£25.95



SUPER-SENSITIVE MICROBUG



Only 45x25x15mm, including built-in mic. 88-100MHz (standard FM radio). Range approx. 300m depending on terrain. Powered by 9V PP3 (7mA). Ideal for surveillance, baby alarm etc. **XK128** **£6.35**

NEW

REMOTE CONTROL DIMMER KIT

Imagine controlling the brightness of your lights or switching them on or off from the comfort of your armchair! This kit contains all the components from front panel to the last screw to enable you to do just that and fit the shallowest wall boxes. Max power 300W (not fluorescents). **XK132****£19.95**

IR TRANSMITTER KIT

Designed for use with the XK132 and comes complete with a pre-drilled box. A PP3 9 volt battery is required. **MK 6****£4.95**



XK136 TOUCH DIMMER KIT**£12.95**

VERSATILE REMOTE CONTROL SYSTEM

These kits can switch up to 16 pieces of equipment on and off or control 16 functions depending on the keyboard selected for the MK18 transmitter. MK12 receiver has 16 logic outputs and operates from 12 to 24V d.c. or 240V a.c. via the transformer supplied. The MK18 requires a 9V battery and keyboard. Great for controlling lights, TVs, garage doors etc.

MK12 IR Receiver**£19.55**

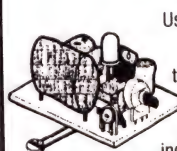
MK18 Transmitter**£8.95**

MK 9 4-way Keyboard**£2.75**

MK10 16-way Keyboard**£7.95**

601 133 Box for transmitter**£2.95**

PROPORTIONAL TEMPERATURE CONTROLLER KIT



Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc.

Maximum load 3kW (240V AC).

Temperature range up to 60°C.

Size 50x40x25mm. **XK140****£8.95**

TK ELECTRONICS

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ELECTRONICS

EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The No.1 Magazine for Electronic & Computer Projects

VOL. 19 No. 12 **December '90**

DEDICATED

I think I'm right in saying that the Light Sequencer in this issue is the first project we have published that uses a "dedicated" chip. In fact this statement is perhaps a little misleading because the chip is an 8-bit CMOS microcontroller with 8K bytes of EPROM and 256 bytes of RAM on board. The EPROM has been specially programmed for this unit and thus the "dedicated chip" is produced.

The advent of such a cheap microprocessor chip (less than £15 for one off) which can be programmed in small quantities in this way does open up the possibilities for various dedicated controllers that are now within the hobbyists price range. Previously the cost of development and production of low volume dedicated chips was prohibitive and the obvious answer was to use a microprocessor with a separate EPROM which could then be cheaply "blown" with appropriate software. The new device is essentially the same animal all on one chip, together with some RAM for user programming. There is even the option of battery back up to protect any user programs when the unit is not turned on.

The controller has, in this case, been pre-programmed with over 100 different lighting sequences that can be run individually or set to step one after the other, each being shown a few times before the next one is selected. This unit thus provides an incredibly versatile lighting unit which is compact, inexpensive and easy to use.

NOW READ THIS!

For those of you who read your magazine what follows might be a bit of a surprise, for the rest – well they won't read it anyway! Time and again people phone us for general information, 'phone numbers, addresses or prices of items that are clearly shown in the magazine. If you want information on the books we supply check the *Direct Book Service* pages; on p.c.b.s, see that page; for back numbers, subscriptions, binders and technical queries it's all on this page. If it's a query on component buying for one of our projects then the answer may be in *Shop Talk*. But of course you know all that, because you read the mag – how do we get at the others?

Mike Kenward

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8 CHANNEL MICROCONTROLLER LIGHT SEQUENCER

MARK STUART

Complete fingertip control for lighting effects for Discos and Stage shows are made possible by the use of a pre-programmed microcontroller chip.

THIS sequencer was designed to open up a new range of lighting effects for Discos, Stage Effects, and Commercial Displays at a reasonable price. It will no doubt find many other uses because of its versatility and low cost.

The circuit is based upon a pre-programmed microcontroller i.c. which drives eight triac mains switches via opto-isolators, and provides a full front panel mimic display along with four other indicators which display the current operating mode. The i.c. is controlled by a twelve key keypad, providing the following functions:

SELECT MODE:

Select lamp ON

- 1) Select pre-programmed sequence from memory by entering keypad code. Select from over 100 sequences, including standard 3 and 4 channel chases and a vast range of others including random and Light Rider eight lamp end-to-end sequences.

RUN MODE:

Run lamp ON

- 2) Runs the selected sequence, or continuous selection if none selected. Increase Speed / Decrease speed; continuously and smoothly varies sequence speed whilst running using UP/DOWN keys.

STOP MODE:

Stop lamp ON

- 3) Stop sequence at any position and individually control each lamp by use of its number button. Alternate toggle action: Press once for ON, once for OFF and so on. Useful for setting up colour effects.

STEP MODE:

Stop lamp ON and Step lamp ON

- 4) Automatically steps through the selected sequence one step at a time each time the STEP key is pressed. An external switch or contact pad may be connected to allow manual stepping to music beat.

FULL SEQUENCE MODE:

Run lamp ON

- 5) After switch on this mode is entered automatically. The controller runs through its entire sequence memory, running each sequence a number of times and then stepping on. At the end it returns to the first sequence and repeats.

PROGRAM MODE 1:

Stop lamp ON and Select lamp ON

- 6) Up to ten sequences each 16 steps long may be entered step by step and stored in memory. These are held in memory by on chip battery backed RAM. Any number of lamps may be on or off in each step.

PROGRAM MODE 2:

Stop lamp ON and Select lamp ON

- 7) A single sequence up to 160 steps long may be entered step by step and stored in memory. As with Mode 1, Battery Backed RAM is used. This program is particularly useful for stage effects and display lighting. The sequence may be stepped manually or run automatically, and will repeat continuously.

Note that Program Modes 1 and 2 cannot be used at the same time as they use the same memory space.

SAFETY

The 8-Channel Microcontroller Light Sequencer is compact and uses two standard 8 way sockets for lamp connections. All channels are individually fused. Sequence patterns are provided which allow existing three- and four-channel lamp set ups and rope lights to be connected, and give much better effects than standard chasers. The two 8 way sockets can be used simultaneously with different sequences programmed for each, provided that they are run at the same speed.

Opto-isolators are used to maintain all of the control board electronics at safe low voltages completely isolated from the mains. All lamps are switched at the mains Zero Crossing point to minimise interference and stress to the lamps and triacs.

The triacs are connected to the "Live" side of the mains for added safety, so that when they are off there is no mains live connection to any of the lamps. A double pole mains isolating switch is also used for additional safety.

CIRCUIT DESCRIPTION

The circuit diagram for the 8-Channel Microcontroller Light Sequencer is really straightforward but looks complicated because many parts are repeated eight times.

The power section and the control section are built on separate printed circuit boards and have been drawn as separate circuits. Either one may be used without the other in conjunction with other equipment. In particular the Power Board is *fully isolated* and can be driven from a computer I/O port or other low power circuits to control a range of mains powered equipment.

The Control Board could be operated from 12V d.c. and be fitted with power Darlington transistors to drive 12V lamps for use in car displays.

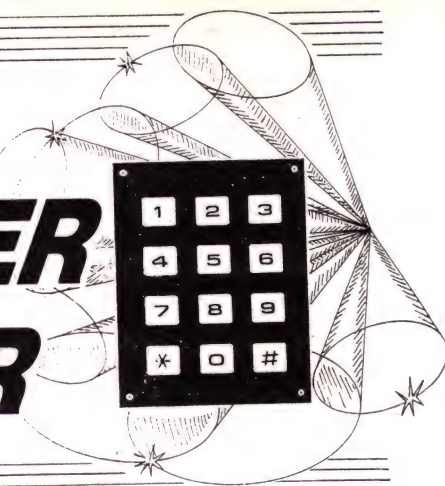
It is also practical to drive more than one power board from a single control board so that power boards can be built into the lamp units and connected using thin signal cables to a central controller.

POWER SECTION

The complete power section circuit diagram is shown in Fig. 1. Triacs CSR1 to CSR8 switch the mains Live via the bank of eight fuses to the output sockets. Triac CSR8 has a resistor R31 between its gate terminal and its common or MT1 terminal. This resistor holds the gate at the same voltage as MT1 and so the triac is held in the off state. It is inappropriate here to go into full detail about the operation of triacs, but a simple explanation will help the rest of the circuit to be understood better.

Normally a triac is in the OFF state and current cannot flow between its MT1 and MT2 terminals (MT stands for Main Terminal). A small current passed between the gate terminal and MT1 (the Gate Current) turns on the triac so that current can flow in either direction between the two Main Terminals.

If the gate current is now removed the triac will remain turned ON provided some current is still passing between the Main Terminals. With an a.c. supply the current is reduced to zero each time the voltage reverses between half cycles (this happens 100 times per second for 50Hz mains).

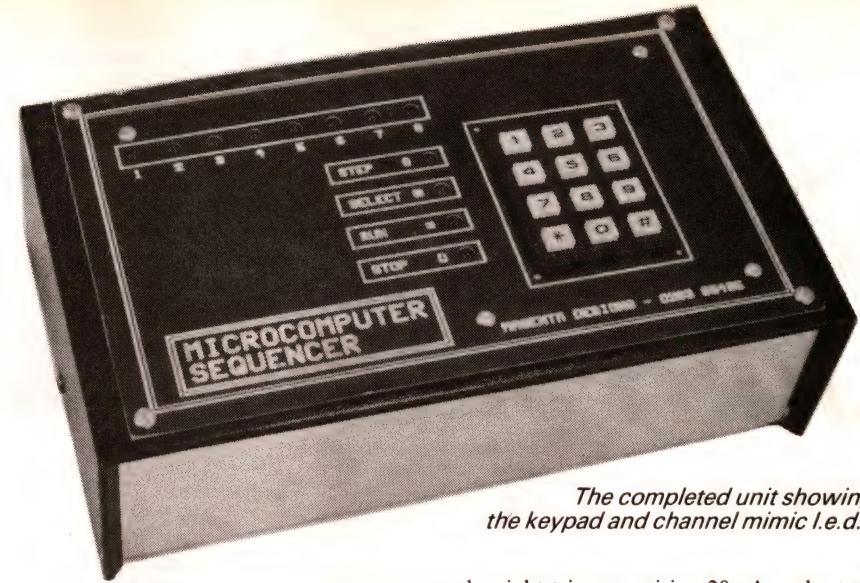


A triac turned on with a short pulse of gate current just after the beginning of a mains half cycle will therefore remain conductive until the mains voltage and current fall to zero at the end of the half cycle. To maintain a triac in what is effectively a permanently ON state only a small pulse of gate current is required after the beginning of each mains half cycle.

This is true with resistive loads such as lamps and heaters where the current rises as soon as voltage is applied, but with more complicated loads such as transformers and fluorescent lamp chokes, the current does not rise immediately, and so the gate current pulse comes and goes before sufficient current has built up between the Main Terminals to maintain the triac in the ON state. (There is a minimum current called the Hold Current which is required between the Main Terminals to maintain conduction, typically it is equal to the minimum gate current required to start conduction.)

PULSE TRIGGERING

To deal with these more complicated loads the ideal method is Hard Triggering, where gate current is applied continuously.



The completed unit showing the keypad and channel mimic l.e.d.s.

This has only one drawback which is that it increases the current demand from the gate control circuit.

In this circuit it is particularly difficult to provide hard triggering because there could

be eight triacs requiring 20mA each at the same time. This current is not available from the 20V tapping on the transformer being used and so an alternative method is used to combine low current operation and yet provide triggering over all of the mains cycle.

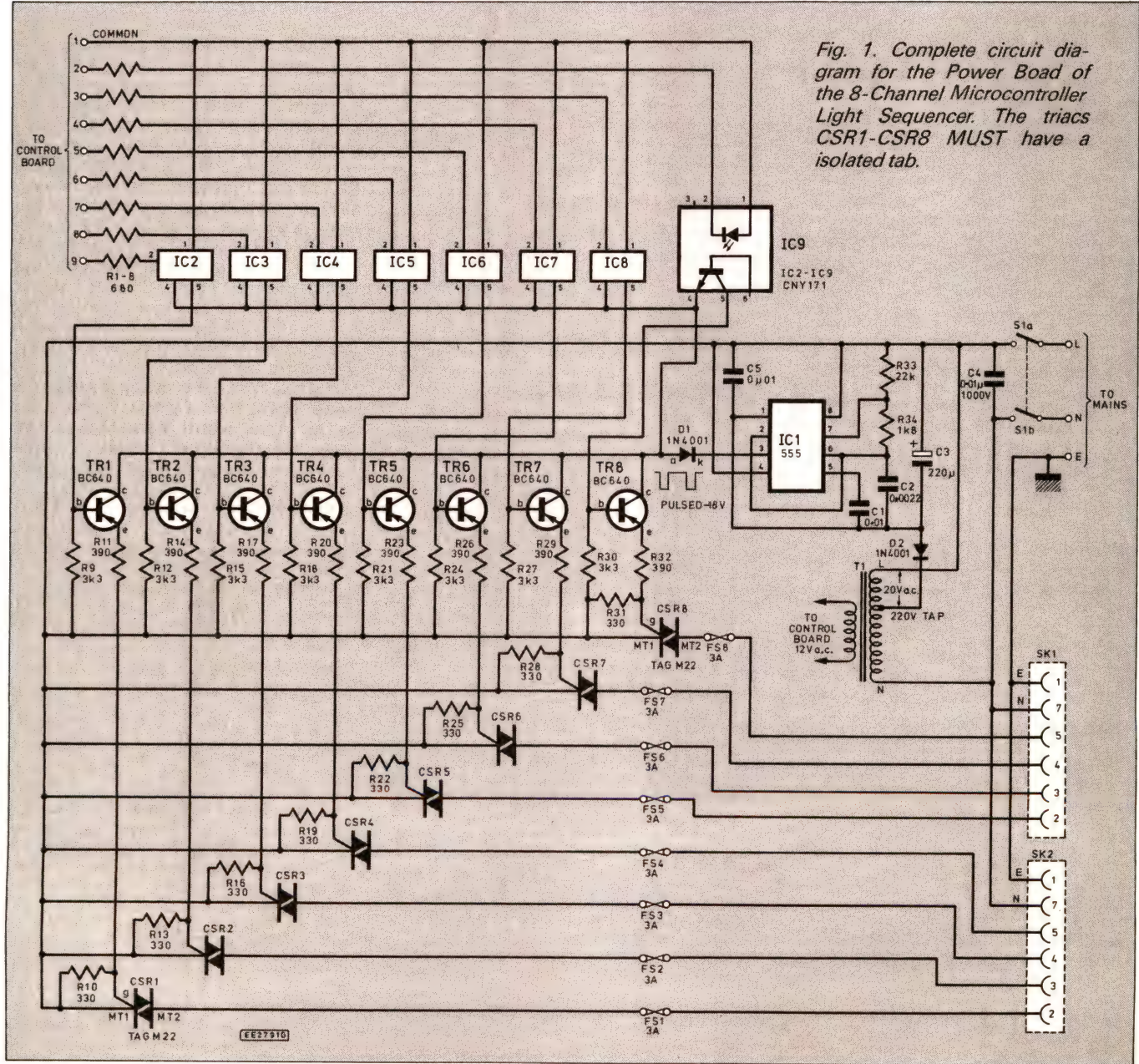


Fig. 1. Complete circuit diagram for the Power Board of the 8-Channel Microcontroller Light Sequencer. The triacs CSR1-CSR8 MUST have a isolated tab.

Instead of applying gate current continuously it is applied in pulses throughout the mains cycle. The mark-space ratio of the pulses is 1 to 10 so that the average current flowing is one tenth of the peak.

The result is that 20mA gate pulses are available for only 2mA of supply current. The pulse rate is over 10kHz so that there are over 100 pulses per half cycle, a rate which is practically indistinguishable by the triac from continuous current.

TRIGGER CIRCUIT

Trigger pulses are produced by a standard 555 timer (IC1) operating in the astable mode. The circuit is powered from a 20 volt tapping (see Fig. 1) on the mains transformer primary after rectification by diode D2 and smoothing by capacitor C3.

The timing components are resistors R33, R34, and capacitor C2. Capacitors C1 and C5 provide essential decoupling for stable operation. The output of this circuit is a series of 18 volt negative pulses which are passed via diode D1 to the trigger circuits of the eight triacs.

Triacs are not too worried about the direction of the gate current and turn on happily with "positive" or "negative" drive. Negative drive has been chosen because the 555 timer is easier to use producing negative pulses and a simple circuit results. Also there is a slight increase in gate sensitivity when negative pulses are used.

Gate current to the triacs is supplied via transistors TR1 - TR8 which act as emitter followers, amplifying the small current available from the phototransistor inside the opto-isolators IC2 - IC9. The emitter resistors R32 etc. limit the maximum peak gate current to 20mA.

Resistor R30 is the load resistor for IC9 and determines the current which is required from the phototransistor to produce full gate drive. The value of 3k3 chosen requires 3mA to produce the 10V required for full drive at the base of TR8.

The l.e.d. side of the opto-isolator is completely insulated from the phototransistor and so provides complete mains isolation. Current in the l.e.d. illuminates the phototransistor and turns it on.

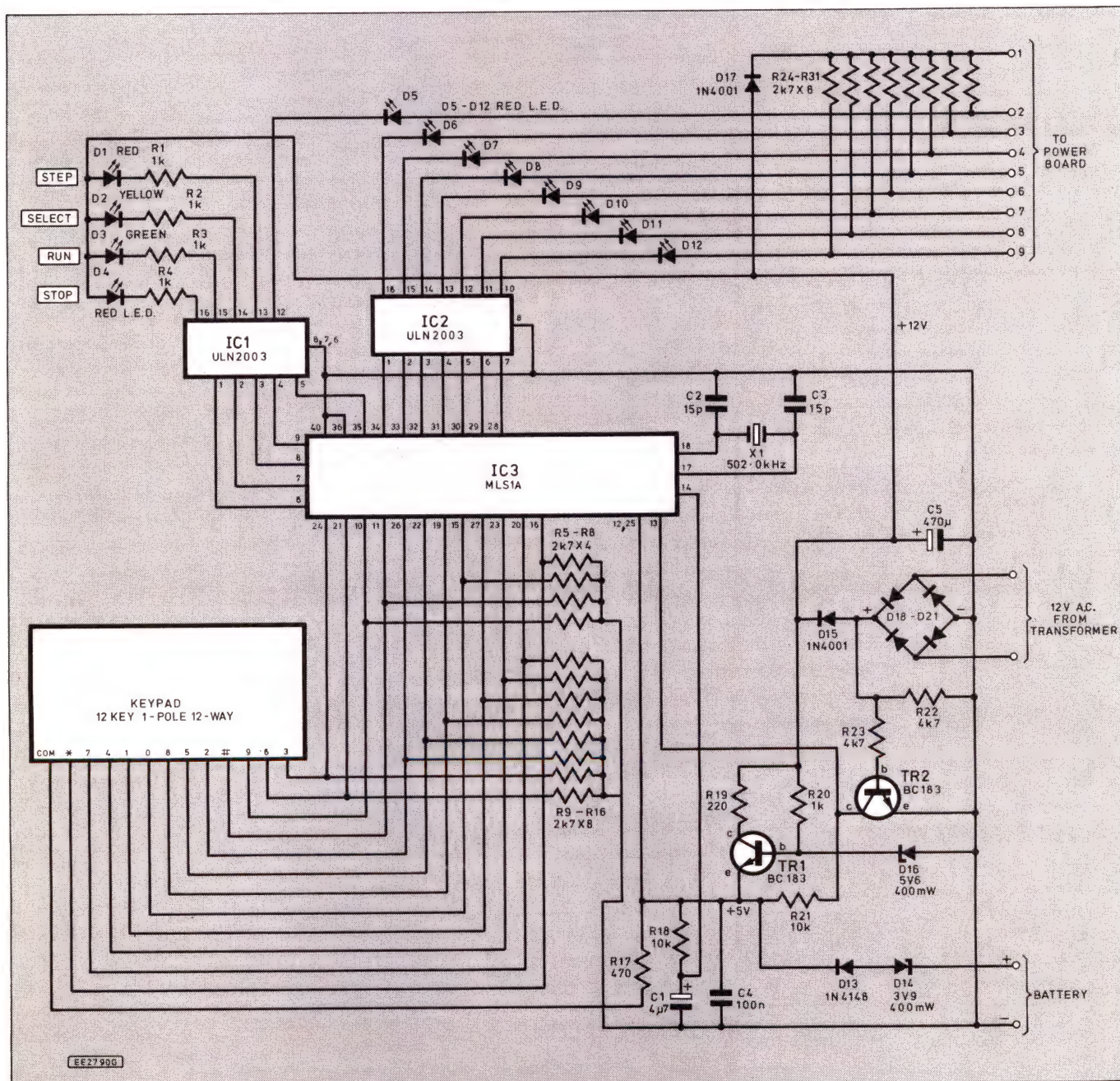
The CTR or Current Transfer Ratio of the opto-isolator indicates the ratio of phototransistor current to l.e.d. current. Average units give between 80 per cent and 20 per cent and so the design should allow for 20 per cent.

If 3mA is required from the phototransistor then with 20 per cent CTR the l.e.d. current should be $3 \times 100/20$ or 15mA. This sets the value of the series limiting resistors R1 to R8. In practice most opto-isolators will be well above this level of sensitivity and so ample current has been provided.

Sockets SK1 and SK2 provide two standard output connectors and are wired to match most commercial chasers. This allows existing three- and four-channel lamp units to be connected without re-wiring.

The secondary winding on the transformer is of course completely insulated from the mains and so provides an isolated supply for the control board. Capacitor C4 is a mains rated component that helps to reduce mains spikes and prevent them from triggering the triacs and upsetting the control board microcontroller.

Fig. 2. Complete circuit diagram for the control section of the 8-Channel Microcontroller Lights Sequencer.



CONTROL SECTION

The complete circuit diagram for the control section is shown in Fig. 2.

The Control Board uses a special pre-programmed Microcontroller i.e. which reads the keypad, drives the indicators and opto-isolators and works out the timing to ensure zero volt switching takes place correctly. It also contains a large array of sequences programmed into its ROM area and has an area of RAM that can be programmed with special sequences by the user.

As IC3 does most of the work the rest of the circuitry is simplified greatly and consists of a power supply, output buffers, a mains zero cross detector, and assorted pull-up and pull-down resistors. An optional battery backup connection is available to retain user programmed sequences.

INPUTS

The keypad is a one-pole 12-way type that connects straight into IC3. Resistor networks containing R5 to R8 and R9 to R16 pull the inputs down to zero without any keys pressed.

Pressing a key pulls the corresponding input high via resistor R17 which connects to the 5V rail. More than one key can be operated at a time in some modes in which case several inputs are pulled up together.

OUTPUTS

Outputs from IC3 are buffered by the Darlington drivers, IC1 and IC2. These contain seven separate stages each and so one section of IC1 and all of IC2 are required for the eight sequence outputs. Four other sections of IC1 are used to drive the four function indicator l.e.d.s (D1 to D4) via resistors R1 to R4.

All of the outputs from IC1 and IC2 are open collectors which turn on when the input voltage is 5V and off when it is zero. They have a current capability of 500mA each which is enough to drive several power boards.

The outputs to the power board are driven via the mimic l.e.d.s D5 to D12. These are in series with the opto-isolator l.e.d.s which are fed from the 12V positive supply rail via diode D17. Resistor network R24 to R31 contains eight resistors which allow a small current to flow in the l.e.d.s when the power board is not connected. This allows the control board to be tested fully on its own with just a 12V a.c. supply.

CLOCK

A 502kHz ceramic resonator X1 connected between pins 17 and 18 of IC3 provides the clock signal from which the microcontroller derives all of its internal timing functions. Capacitors C2 and C3 provide the necessary loading and phase shift to ensure oscillation.

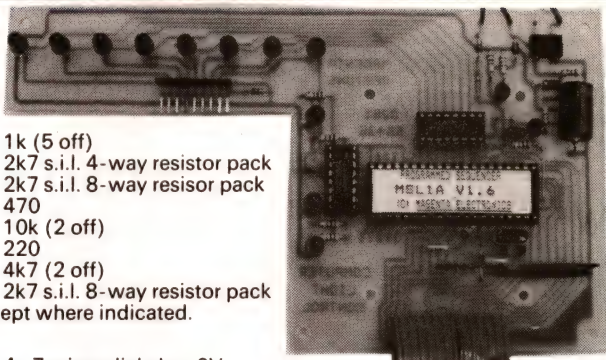
POWER SUPPLY

The 12V a.c. from the transformer secondary is rectified by the d.i.l. bridge rectifier containing D18 to D21. Before smoothing, the full wave rectified output is fed to transistor TR2 base via resistor R23. As long as the input exceeds 0.6V TR2 is turned on and holds the voltage at pin 13 of IC3 at zero.

When the voltage falls below 0.6V, which it does around the mains zero crossing points, TR2 is turned off and the voltage on its collector and on pin 13 of IC3 is

COMPONENTS

CONTROL BOARD



Resistors

R1-R4, R20	1k (5 off)
R5-R8	2k7 s.i.l. 4-way resistor pack
R9-R16	2k7 s.i.l. 8-way resistor pack
R17	470
R18, R21	10k (2 off)
R19	220
R22, R23	4k7 (2 off)
R24-R31	2k7 s.i.l. 8-way resistor pack

All 0.25W 5% carbon except where indicated.

Capacitors

C1	4 μ F min radial elec. 6V
C2, C3	15p ceramic (2 off)
C4	100n ceramic, 50V
C5	470 μ F min. axial elec. 16V

Semiconductors

D1, D4, D5-D12	5mm red l.e.d. (10 off)
D2	5mm yellow l.e.d.
D3	5mm green l.e.d.
D13	1N4148 signal diode
D14	3V9 400mW Zener diode
D15, D17	1N4001 1A 50V rec. diode (2 off)
D16	5V6 400mW Zener diode
D18-D21	d.i.l. bridge rec.
TR1, TR2	BC183 npn silicon transistor (2 off) (NOT BC183L)
IC1, IC2	ULN2003 Darlington driver (2 off)
IC3	MLS1A programmed sequencer (Magenta)
X1	502.0kHz ceramic resonator

Miscellaneous

Keypad, 12 key 1-pole 12-way; printed circuit board available from the *EE PCB Service*, code EE708; 9-way 90° 0.1in. pitch pin header; 16-pin i.c. socket (2 off); 40-pin d.i.l. socket; single sided p.c.b. screening panel, 185mm x 106mm; mounting pillars and long screws (4 off); nuts (8 off); solder tag (2 off); washer; solder, etc.

See
SHOP
TALK
Page

POWER BOARD

Resistors

R1-R8	680 (8 off)
R9, R12, R15, R18, R21, R24, R27, R30	3k3 (8 off)
R10, R13, R16, R19, R22, R25, R28, R31	330 (8 off)
R11, R14, R17, R20, R23, R26, R29, R32	390 (8 off)
R33	22k
R34	1k8

All 0.25W, 5% min. carbon film

Capacitor

C1, C5	0 μ 01 ceramic, 50V
C2	0 μ 0022 Mylar, 50V
C3	220 μ F radial elec. 25V
C4	0 μ 01 ceramic, 1000V

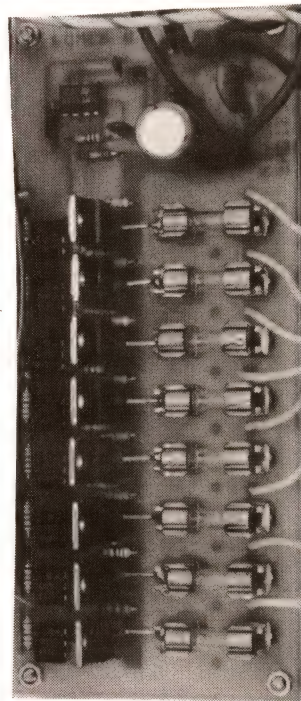
Semiconductors

D1-D2	1N4001 1A 50V rec. diode (2 off)
TR1-TR8	BC640 pnp transistor (8 off)
CSR1-CSR8	TAG M22 isolated tab triac (Magenta) (8 off)
IC1	NE555 timer i.c.
IC2-IC9	CNY171 opto-isolators (8 off)

Miscellaneous

T1	3VA Mains transformer, with 220V primary tapping; 12V secondary (wire-ended connections)
S1	DPDT 13A mains rocker switch
FS1, SK2	8-pin chassis socket - P552 (2 off)
FS1-FS8	3A 20mm quick-blow fuse (8 off), with 0.4in. pitch fuse clip (16 off) - see text.

Printed circuit board available from *EE PCB Service*, code EE709; metal case, 230mm x 133mm x 63mm; 8-pin i.c. socket; 10A 250V mains cable; mains cable entry clamp; "star" or 3-way solder tag; self-tapping screws (4 off); insulating sleeving; solder, etc.



Approx cost
guidance only

£56

pulled up to 5V via resistor R21. This pulse which occurs every cycle is used by IC3 to determine when the mains cycle is crossing zero and is used to synchronise the sequence so that steps only occur at this time.

The rectified 12V is passed via diode D15 to smoothing capacitor C5. From here a simple regulated supply of 5V is provided via a standard emitter follower regulator consisting of Zener regulator diode D16, transistor TR1 and resistors R19, R20. This is a simple short-circuit proof regulator that protects IC3. C4 is a decoupling capacitor which keeps voltage spikes off the supply line.

Diodes D13 and D14 allow a 9V battery to power IC3 for intervals between use so that it can store the user entered programs. Just leave out the battery if this feature is not needed.

RESET

Two remaining components provide the vital function of resetting IC3 at switch on. This is necessary so that it knows where to begin.

As power is applied IC3 pin 14 is temporarily held at zero volts by capacitor C1 holding the microcontroller in the starting

condition. As C1 charges via resistor R18 pin 14 rises to 5V and operation begins.

This action is not required when battery backup is used and the circuit re-starts automatically.

CONSTRUCTION

Before doing any electronic construction the case should be prepared. As there is a fair amount of drilling it is recommended that those without the necessary tools or skills might like to buy the kit version, which is supplied with a drilled case and fascia panel.

Those who enjoy "metal bashing" may buy the version with a blank case or may chose to make their own housing. A paper drilling template is available free from Magenta.

Alternatively it is quite effective to use the bare printed circuit boards as an aid to marking out to ensure that the mounting holes and l.e.d. drillings are made correctly. The power board should be fitted with its front edge 4mm from the front panel of the case to allow the heatsink (if used) to fit correctly.

The keypad position is not critical but should be approximately as shown. The

sockets, switch and cable entry clamp on the rear panel must be mounted as low as possible to ensure there is enough room for the control board in the top of the case.

The best method of cutting out the larger holes is to use an Abraframe saw which can cut in all directions. First drill a pilot hole and then thread the blade and re-fit it to the saw frame. If the case has been marked out well it is fairly easy to make good holes in this way. A smooth file finishes the job.

A rectangular piece of copper clad board is needed to act as a screen and an "earthed" safety barrier mounted on the rear of the control board. This board must be cut to 102mm x 180mm and drilled using the control board as a template so that it fits with its *unclad* side facing the track side of the control board.

The rear panel holds the ON/OFF switch, mains cable entry clamp, output sockets, and most important of all, a star earthing tag. This should be fitted using a single screw fitted with shakeproof washers and two nuts. It is *NOT* acceptable to use a component mounting point for earthing purposes.

When all of these components have been mounted the mains connections should be

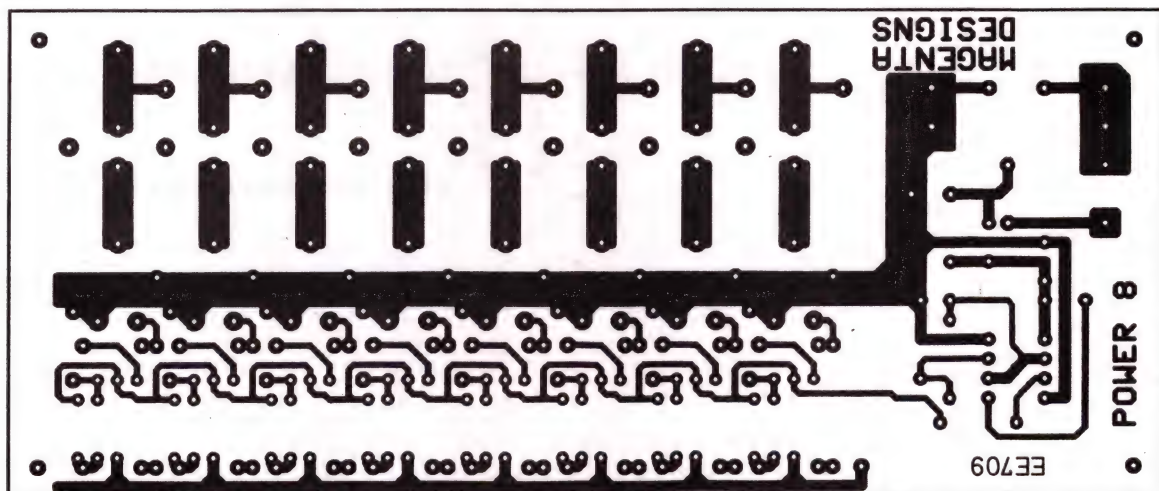
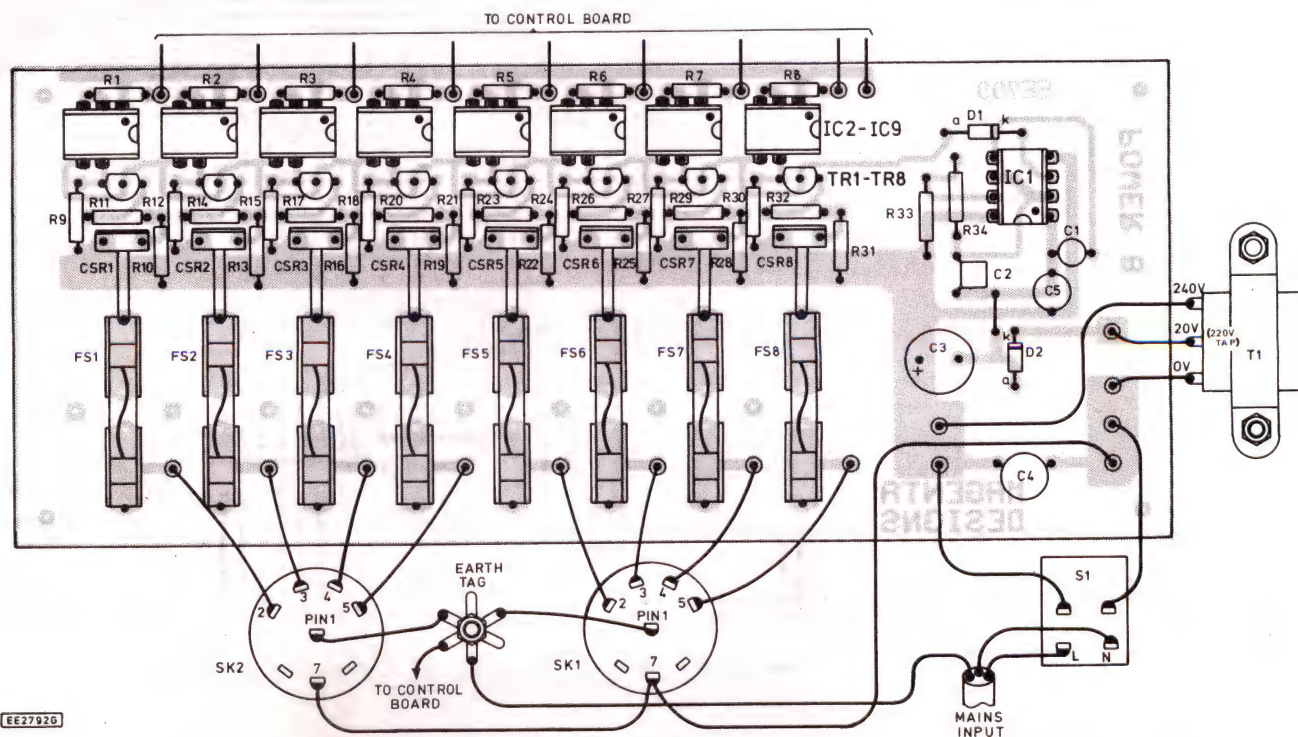


Fig. 3. Printed circuit board component layout and full size copper foil master for the Power Board



made between them following the wiring diagram Fig. 3. All mains connections should be covered with insulating sleeving.

POWER BOARD

The component layout and full size copper foil master pattern of the Power Board is shown in Fig. 3. Fit all of the resistors first. Care is required because they are closely spaced to keep board area to a minimum. It is best to fit R11, R14, etc first.

Next fit the opto isolators, IC2 to IC9, *directly* to the board. Sockets should not be used as they reduce the clearance between

The centre leads of the triacs must be bent 3mm from the plastic case towards the non metal side. The other two leads should then be inserted into the board down to the shoulder on the pins and soldered in.

Straighten the triacs up on the board and then solder the centre leads to the point where the fuseholder tag passes into the board. It is important that the correct isolated tab triacs are used. Each one **MUST** be checked before insertion by an ohmmeter between the centre lead and the tab to ensure that there is NO connection.

The remaining connections between the mains input and the transformer should be

left until later, because the board can be tested at low voltage before making these final connections.

CONTROL BOARD

The construction of the Control Board requires care because the i.e.d.s must be aligned with the front panel drillings. It is best to do this first without the clutter of other components. The Control Board component layout and full size printed circuit copper foil master pattern is shown in Fig. 4.

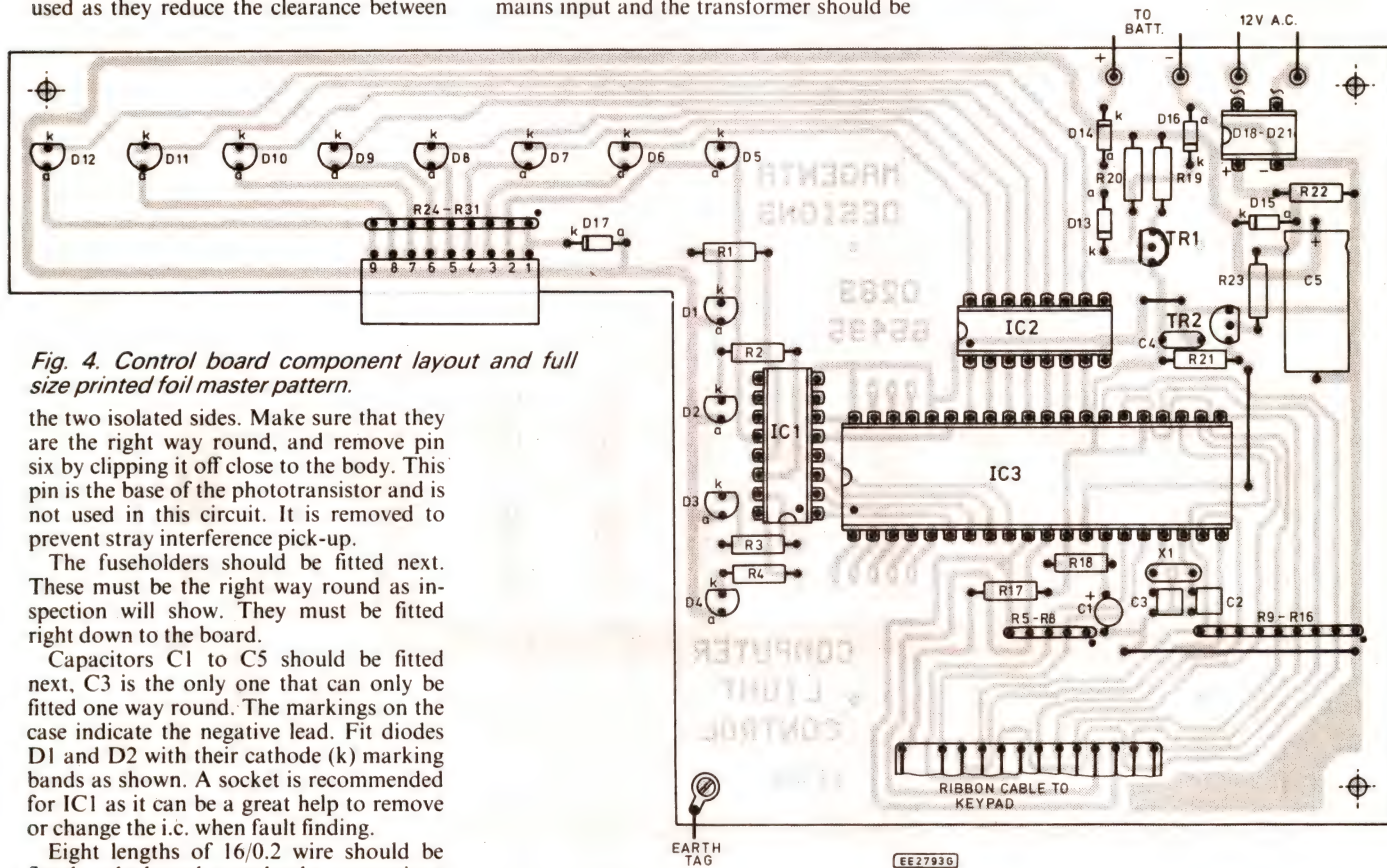


Fig. 4. Control board component layout and full size printed foil master pattern.

the two isolated sides. Make sure that they are the right way round, and remove pin six by clipping it off close to the body. This pin is the base of the phototransistor and is not used in this circuit. It is removed to prevent stray interference pick-up.

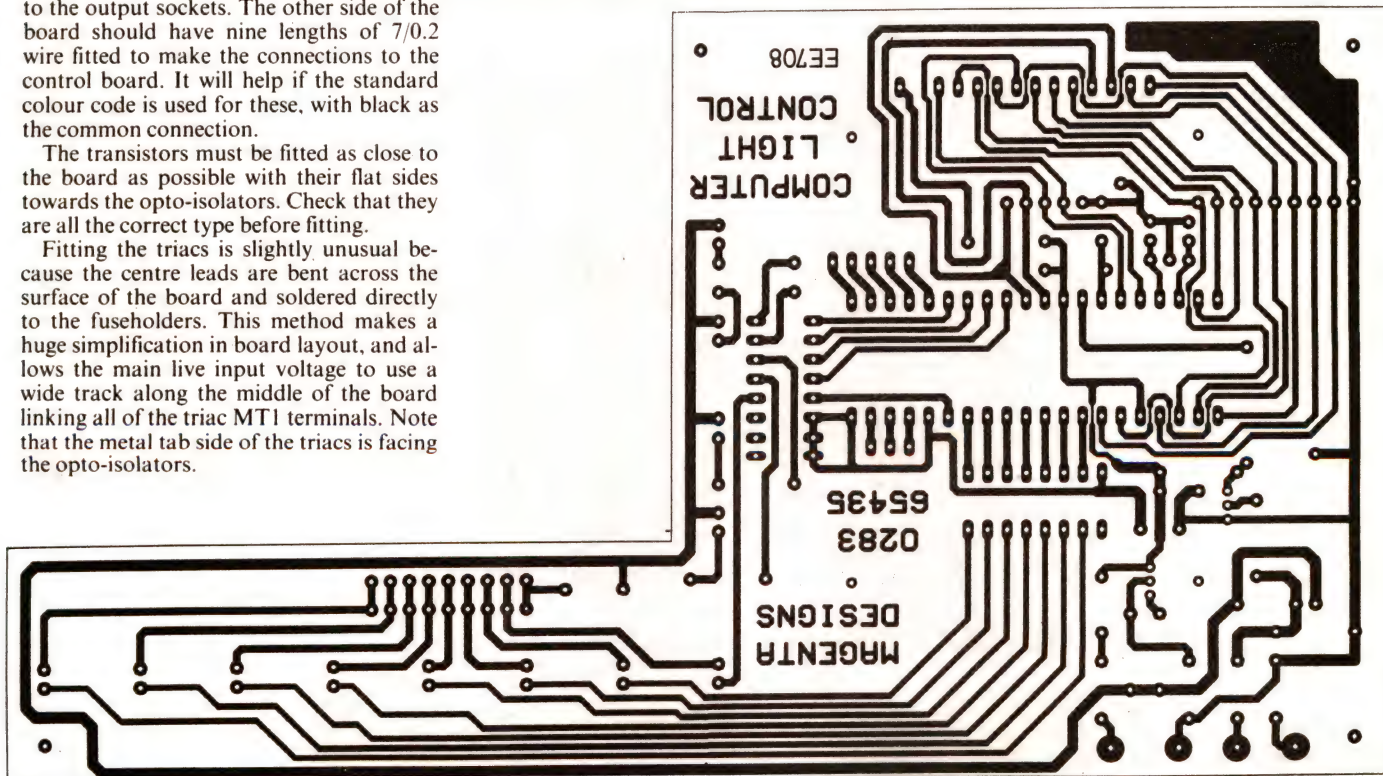
The fuseholders should be fitted next. These must be the right way round as inspection will show. They must be fitted right down to the board.

Capacitors C1 to C5 should be fitted next, C3 is the only one that can only be fitted one way round. The markings on the case indicate the negative lead. Fit diodes D1 and D2 with their cathode (k) marking bands as shown. A socket is recommended for IC1 as it can be a great help to remove or change the i.c. when fault finding.

Eight lengths of 16/0.2 wire should be fitted to the board to make the connections to the output sockets. The other side of the board should have nine lengths of 7/0.2 wire fitted to make the connections to the control board. It will help if the standard colour code is used for these, with black as the common connection.

The transistors must be fitted as close to the board as possible with their flat sides towards the opto-isolators. Check that they are all the correct type before fitting.

Fitting the triacs is slightly unusual because the centre leads are bent across the surface of the board and soldered directly to the fuseholders. This method makes a huge simplification in board layout, and allows the main live input voltage to use a wide track along the middle of the board linking all of the triac MT1 terminals. Note that the metal tab side of the triacs is facing the opto-isolators.



Insert the l.e.d.s into the board but do not solder them. With the l.e.d.s in position fit the board to the front panel using long screws and 12mm spacers. In this position the l.e.d.s can be fitted one by one into their front panel holes so that their lenses fit evenly, and then soldered in place.

When this is done, remove the front panel and fit all of the resistors and capacitors, the wire links and the resistor networks. Note that the resistor networks have a dot marking the common end which must match the dot in Fig 4. Curious things will happen if they are the wrong way round. Capacitors C1 and C5 must be fitted correctly as they are polarised.

All three i.c.s should be fitted in sockets. IC1 and IC2 are power types which can be damaged by short circuits, and IC3 is CMOS. There are no particular handling difficulties with any of the i.c.s, but make sure they are the right way round, and fit them only after testing the power circuits.

The bridge rectifier should be soldered directly into the board in the direction shown. Transistors TR1 and TR2 are the same type and must be fitted with their flat sides as shown. Diodes D14, D15, D16, and D17 need careful identification using a magnifier and must be inserted with their cathode (k) marking bands as shown.

There are three wire links, the two longer ones should be made from insulated wire, or tinned wire fitted with sleeving. Wiring between the keypad and the board requires 13 equal lengths of 7/0.2 wire or a short length of 0.1in. pitch ribbon cable. A length of approximately 50mm allows plenty of room to move the keypad away from the board when testing and is short enough to be tidy in the final assembly.

Standard ribbon can be used but it is flimsy and awkward to handle. Those constructors who prefer to use a different case can extend the keypad leads up to 300mm without problems as long as they are kept clear of mains carrying wires and other sources of interference.

Finally the 0.1in. pitch connector should be fitted next to R24 - R31. A standard straight connector is used with its pins bent over just above the moulded insulator. This is best done before inserting the connector into the board.

Two wires carrying 12V from the mains transformer need to be extended with 7/0.2

wire and the joins insulated with sleeving. These connections are made directly to the control board next to the bridge rectifier.

The nine leads from the power board must be routed as shown in the photographs and clipped inside the front of the case alongside the 12V power leads using a self-adhesive cable retainer. Cut the nine leads to equal lengths, strip 4mm of insulation from the ends and crimp on the female connectors for the 0.1in. pitch connector. A pair of pointed pliers will produce an adequate crimp which can be further secured by soldering for extra reliability.

The finished crimp tags are fitted into the rear of the housing so that the small barbs engage with the slots. They can be withdrawn if they are fitted in the wrong order by pressing in the barbs to release them.

A 10-way connector shell must be used as 9-way ones are hard to get. The unused position can be used as a polarising key by blocking the hole with a small piece of plastic.

TESTING

Before further assembly the power and control boards should be tested separately.

Begin with the Control Board. IC3 must be left out and the back up battery disconnected. The lead to the power board should also be unplugged.

Temporarily connect the mains transformer primary 0V and 240V terminals to the mains via sleeved connections to the power switch. Carefully insulate the "20V tap" and tie it out of harms way.

Connect the 12V a.c. secondary output from the transformer to the control board. Switch on and check that all lamps are out, that the voltage across capacitor C5 is approximately 16V and that the voltage across diode D16 is 5.6V.

Check that the emitter voltage of transistor TR1 is 5V and that pins 14 and 25 of IC3's socket are both at 5V. If pin 14 reads below 4.5V check R18 and C1. Next check that the voltage on pin 13 reads slightly above zero and rises to 5V when the base and emitter of transistor TR2 are shorted together.

Measure the voltages on the pins of IC3's socket that are connected to the keypad. These should read 0V and rise to above

4V when the corresponding key is pressed. Check that only the correct key changes each pin's voltage. This seems tedious but ensures that everything will go smoothly when IC3 is finally inserted.

The output circuits can now be checked by touching a one kilohm (1k) or similar value resistor between the 5V supply and each output pin in turn. This should result in the corresponding l.e.d.s lighting one by one. Failure of any l.e.d. to light could indicate a fault in IC1 or IC2, or more likely, a reversed or damaged l.e.d.

The l.e.d.s D5 to D12 will be dimmer than the others until the power board is connected, note also that incorrectly fitted resistor networks will produce very odd results. If D5 to D12 all fail to light then the odds are that diode D17 is at fault.

So far so good, now it is time to switch off, carefully insert IC3 and switch on again. If all is well an eight lamp chase sequence should greet the eye! If not, make sure that capacitors C2, C3, and X1 are all correctly fitted and that there are no short circuits or dry joints around them. Check also that the 5V supply is still correct and that pin 13 reads slightly above 0V.

The power to IC3 is current limited by resistor R19 and R20 so it should withstand reversed insertion. Don't forget to look for obvious things such as i.c. pins folding under and missing the socket, unsoldered joints and solder bridges account for 9 out of 10 faults, so check carefully. If the sequence runs correctly, check the action of the control keys and the number keys as explained later in the section headed "Operation". All i.c.s are tested after programming before despatch so any faults are likely to lie elsewhere.

POWER BOARD

Provided the mains connections have NOT yet been made to the Power Board, it is a useful test to connect the 9-way cable to the working Control Board and switch on. The immediate effect should be an increase in brightness of the Mimic l.e.d.s because they now have a current path through the opto-isolator l.e.d.s instead of just resistors R24 - R31.

If no increase occurs check the lead, and that the correct value resistors R1 to R8 are fitted on the power board. Check also that the opto-isolators (IC2 to IC9) are fitted the right way round.

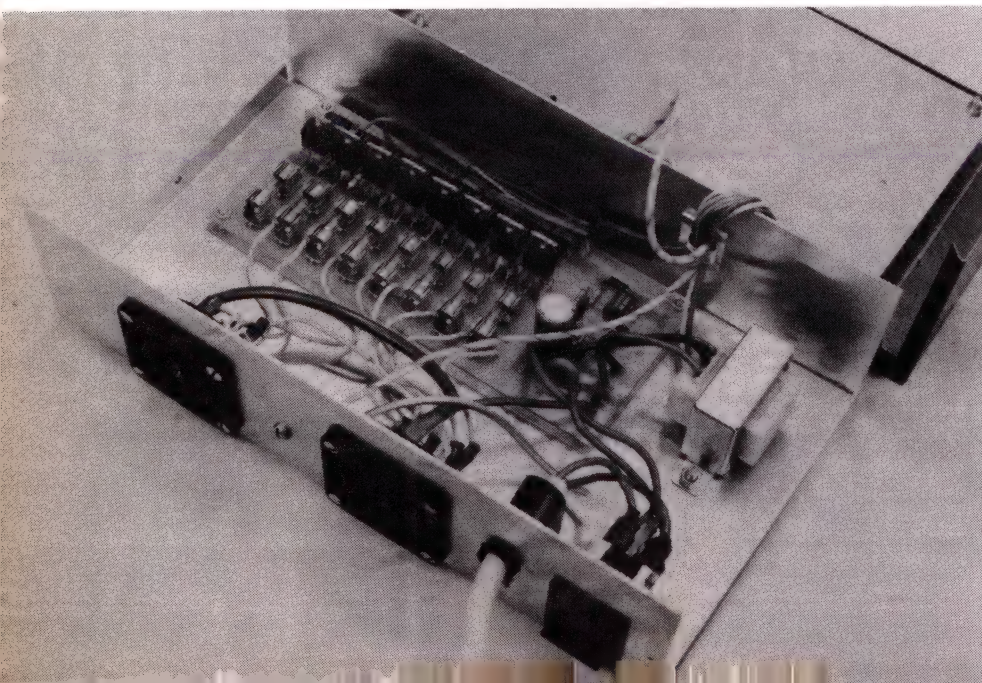
Any l.e.d. that is dimmer or brighter than its neighbours should direct attention to the associated section on the power board. This section of the power board is very simple, consisting of just one l.e.d. (inside the opto-isolator) and a resistor. Any faults should be unlikely.

The circuit on the other side of the opto isolators can not have any effect on these tests. It is easier to carry out these tests if the Stop mode is selected and all of the l.e.d.s are switched individually by their number keys.

The rest of the power board can be tested at low voltage by linking the 12V a.c. supply* used by the control board to the two points on the board where the 240V live, and the 20V tap connections will be made later. **DO NOT MAKE ANY MAINS CONNECTIONS TO THE BOARD.**

The transformer 12V secondary is capable of powering both the control board and the power board during testing. Once these connections have been made, check that the voltage across capacitor C3 is around 16V.

Complete sequencer with top panel removed to reveal the power board, mains transformer and wiring to the output sockets The "screening" panel shields the control panel mounted in the top cover.



The operation of IC1 on the power board can be checked by measuring between pins 3 and 4. Pin 3 should be negative by between 1V and 2V. This is the average reading of the pulsed waveform and will depend upon the meter used, a digital voltmeter could give readings which are way out as it reads the pulses and gaps alternately.

Next temporarily link the anode of diode D1 to the anode of D2 on the power board. This will bypass the pulses and apply 16V continuously to the triac gate trigger circuits. Connect the positive meter terminal to the MT1 terminal of any of the triacs and use the negative test meter probe to measure the voltage in the following tests.

With the control board connected and set in the Stop mode, set all of the l.e.d.s off. Check the voltage at the collectors of TR1 to TR8. This should be close to 15V. Next check the base and emitter voltages which should all be zero. Any irregularities here should direct attention to the corresponding transistors triacs and resistors.

Turn on one channel and check that the base voltage rises to 14V and the emitter to 13V. Check each channel in turn and investigate any differences.

The final test is to check that the triacs are turning on correctly. This can be done at low voltage by connecting a small 12V one or two watt bulb between the cathode of diode D2 and each fuseholder (the end nearer to the triacs). The bulb should turn on and off as expected on each channel.

FINAL ASSEMBLY

Having completed the tests, the transformer should be disconnected from both boards and the power board wiring should be completed. Ensure that the transformer connections to the Power Board are made exactly as shown, a reversed connection here will do some damage by applying near mains voltage to D2 and associated circuits (most of the components on the board).

The Control Board can now be mounted on the front panel by four long screws and 0.5in. pillars. The keypad fits snugly over the board and can be held in position either by sticking it to the front panel or by using the four screw holes.

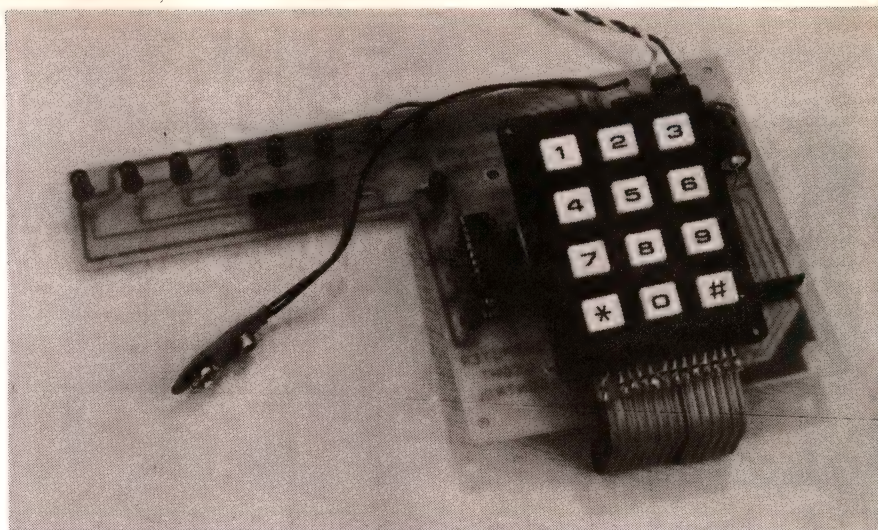
The glue method is neater and provided something like Bostik is used it allows the keypad to be removed if necessary. Check that the connections to the keypad do not contact the inside of the case, use a small strip of tape if necessary to make sure.

One of the control panel mounting screws should be fitted with a solder tag between the pillar and the inside of the front panel. Scrape away some paint to ensure that this tag will make a good Earth contact. When the four panel fixing nuts are fitted the battery clip and 12V a.c. connections should be made to the board.

Clip the 9-way lead to the front panel of the case and plug it into the control board. The leads should allow just enough movement to take off the case top and and lie it face down in front of the case bottom with all connections still made. Finally push the screening panel, plain side down onto the screws holding the control board.

The four nuts should allow sufficient space to accommodate the soldered joints on the rear of the board. If necessary clip any joints that stand too high or use extra nuts.

The Battery should be fitted between this panel and the front panel, using a sticky pad to hold it to the inside of the front. Position the battery so that the clip can be attached and will not fall among the mains connections if it comes loose.



The finished control board with the keypad wired in circuit with ribbon cable. The mimic l.e.d.s can be seen in the top left corner.

A second solder tag must be fitted between the copper side of the screening panel and the final fixing nut. This tag and the one next to the front panel must be linked to the Earthing tag on the case rear panel using green or green/yellow 16/0.2 wire. This lead must be threaded through the solder tag holes and wrapped around to make a good mechanical joint before soldering. Leave enough wire free to enable the case to be opened easily.

HEATSINK

The use of isolated tab triacs allows any type of heatsink to be connected to the triacs without insulation difficulties. In some applications a heatsink will not be required at all, and the circuit can certainly be run for test purposes in this state.

To get the best power output and efficiency requires a piece of 16s.w.g. folded to link the case to the triac tabs, or a piece of solid bar 25mm x 8mm x 100mm drilled to take self-tapping screws through the tabs and to be attached to the case at the other side by similar means. The option chosen is left to the constructor.

POWER

The specified triacs are rated at 8A 250V each. Since all triacs could be on together this gives a maximum rating of 64A! The limit of the mains supply and the surges generated by large tungsten filament lamps gives a very comfortable limit of something under 2A or 500W per channel.

With care, and sensible programming the situation where more than four lamps are on together can be eliminated. This allows 4A or 1000W per channel capability.

Whatever the chosen level of operation, reliability will be very much enhanced by good heatsinking. The aluminium bar method being the best.

The fuses should be as low as possible consistent with the load used. You should find 3A quick blow 20mm types cover most applications, but as with all fuses they cannot be guaranteed to protect the triacs under all conditions.

OPERATION

Running the 8-Channel Microcontroller Light Sequencer is easy, and largely self explanatory. After switch on the RUN mode is entered automatically. The Run lamp lights and the entire range of pre-programmed sequences are run automatically.

To select a particular sequence press the STOP key and the SELECT key. Enter a 3 digit number to select the required sequence followed by the RUN key. If you enter the wrong number, enter the correct three digits before pressing the RUN key. The sequencer acts only on the last three and will run that sequence continuously until another is entered.

To alter the speed of the sequence, press the 9 key for increase or the Hash key for decrease while the sequence is running. Holding the keys for longer produces a greater change.

The sequence can be stopped at any time by pressing the STOP key and can be stepped on manually in this mode by using the 9 key after pressing the STEP key. Lamps can be turned on and off manually whilst in the STOP and STEP mode without interfering with the selected sequence. Returning to RUN mode restores the sequence where it left off.

PROGRAMMING

To program sequences press STOP then STEP and then SELECT followed by a number from 0 to 9. Selecting 0 enters the PROGRAM MODE 2 which allows sequences up to 160 steps long to be entered and run.

Programs are entered one step at a time by setting up the lamps for each step and pressing the STEP key until the required number of steps have been programmed. Steps are entered into memory one byte at a time and are retained indefinitely until re-programmed. Leave the program mode by pressing RUN.

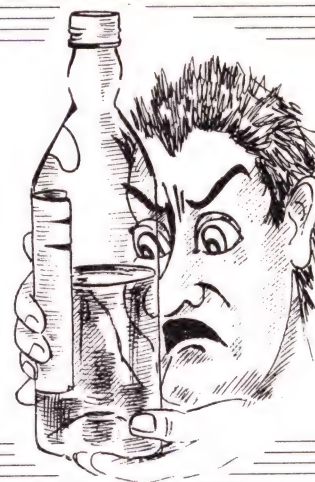
Entering a number from 1 to 9 after STOP, STEP, SELECT enters PROGRAM MODE 1 and allows one of nine sets of 15 step long areas of memory to be programmed. These will run and repeat in the same way as the pre programmed sequences.

The length of the sequence is automatically set when the RUN key is pressed to exit the programming of each sequence. It can be different for each one and be anywhere from one to 15 steps long.

All 15 memory locations are reserved even if the sequence is short, so that the maximum number of user entered programs is nine. It is unlikely that more will be needed because the pre programmed sequences cover most requirements. A full list of the programs is supplied with the i.c., or can be obtained separately. □

ELECTRONIC DIPSTICK

CHRIS BOWES



A novel circuit for measuring the depth of aqueous liquids, indicated by a bargraph display. Ideal for remote sensing.

AFTER a short break, we return to the pocket money projects with an Electronic Dipstick which will enable you to measure the depth of any aqueous liquid in a container. The depth of the liquid is indicated by means of 10 l.e.d.s arranged on a bar display.

This project has a number of potential uses, since the length of the sensor wire is not particularly critical. It may therefore be used for remote sensing of the level of liquid in, for example, the washer bottle of a car.

HOW IT WORKS

This, relatively simple circuit relies on the fact that a high gain transistor, such as the BC109 used in this circuit, provides such a large current gain that, when it is used to control a low current device such as a l.e.d., only a very minute current is required to flow through its base/emitter connection to make a current flow through the emitter/collector circuit. The circuit also relies on the fact that all aqueous liquids allow a very minute current to flow through them, in this case this is sufficient to allow the transistor to "switch" the l.e.d. on.

CIRCUIT DESCRIPTION

The full circuit diagram for the Electronic Dipstick is shown in Fig. 1. At first sight the circuit may appear slightly complex but if you look at it carefully you will notice that it basically consists of one very simple circuit, consisting of one resistor and one transistor and a l.e.d. (with its associated dropping resistor) repeated 10 times. Since the action of each of the driver circuits is identical, it is only necessary to consider the action of l.e.d. D10; the first l.e.d. to be operated.

When the sensor cable is dipped into the liquid sufficiently deeply for the liquid to complete the circuit between the positive power supply rail and the connection to resistor R10 then the movement of the charge carriers in the liquid is enough to cause a very small current to flow between these two points. This can not occur until switch S1 is depressed, connecting the battery to the two power supply rails.

The minute current which flows from the positive power supply rail through the sensor cable also flows, via resistor R10, to the base of transistor TR10. R10 is a 47 ohm

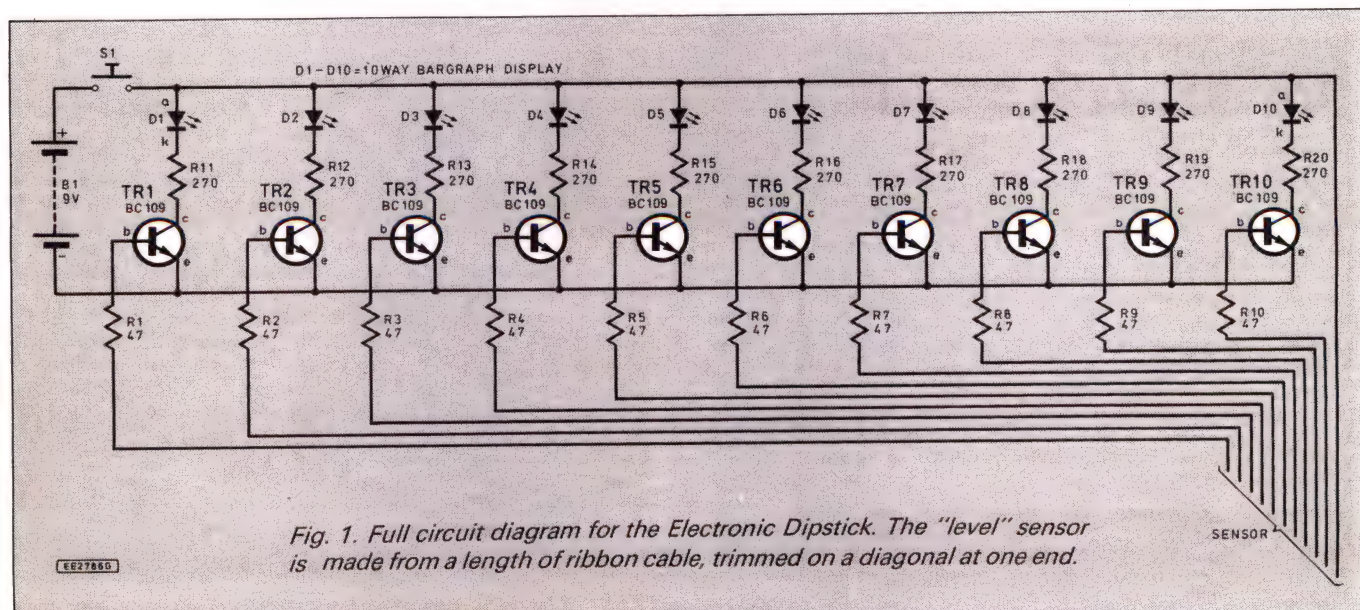
resistor which is incorporated into the circuit to prevent an excessive current flowing through TR10 should a good conductor, such as a metallic object, accidentally short out the connections in the sensor cable.

If resistor R10 were not included in the circuit a direct short between the positive power supply and the base of TR10 would cause the base/emitter voltage of the transistor to exceed the safe limit of approximately 0.7 volts. The action of the transistor would then be to reduce the voltage by dissipating the excess energy as heat. This would cause destruction of the transistor.

The small current which passes through the liquid flows through the base/emitter junction of the transistor TR10 and, in so doing, allows a much larger current to flow through the collector/emitter circuit of the transistor. This in turn allows current to flow through the l.e.d. (D10), causing it to glow. Resistor R20 is included in the collector circuit to reduce the current flowing through the l.e.d. to a safe limit and allow the diode to glow without it being destroyed.

CONSTRUCTION

This project has been designed to be built on two stripboards, main circuit board and display board. It is advisable for the two boards to be constructed separately from each other and for the display board to be tested independently before being connected to the main board.



MAIN BOARD

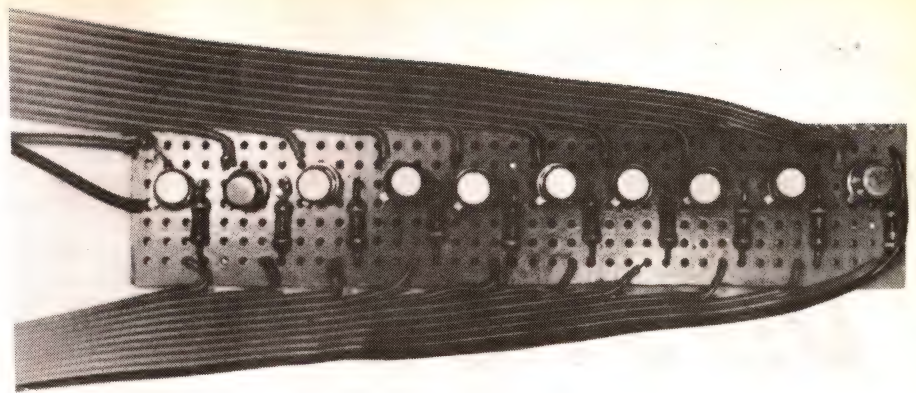
The main circuit requires a piece of stripboard which is 7 strips by 40 holes. The component layout and details of breaks required in the underside copper strips are shown in Fig.2. It is very important that care should be taken to ensure the copper tracks are completely broken, with not even the merest silver of copper left to bridge across the broken track.

Although the operation of the circuit will not be affected in any way by the order in which the components are assembled onto the stripboard you will probably find it easiest to insert the smallest components first, in this case resistors R1 to R10. Care should be taken to ensure that the solder used for these connections is not allowed to bridge between adjacent tracks.

Once the resistors have been soldered into place then the transistors (TR1 to TR10) should be inserted into the correct spaces as shown in Fig.2. It is very important to ensure that the transistors are inserted the correct way round, with the little metal tabs on the transistor case pointing in the direction indicated.

SENSOR CABLE

Once the board mounted components have been assembled on the board and



The completed main driver circuit board.

soldered into place, the next stage of the process is to attach the sensor cable to the stripboard. The sensor cable should be made from a piece of 11 - core ribbon cable.

This size of cable is not a standard conformation and it will be necessary to obtain a larger size of cable and remove the excess cores. Once a suitable length of cable has been prepared one of the cores should be identified as the common positive connection.

Before the sensor cable is connected to

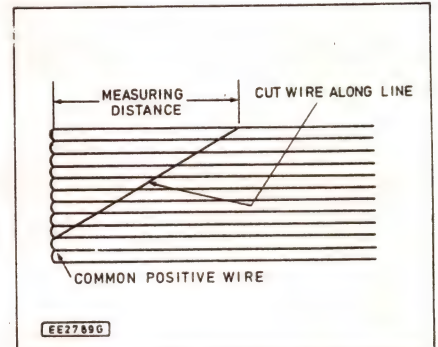


Fig. 3. Preparing one end of the sensor cable.

the main board it should be prepared as shown in Fig.3. The distance through which the range of the liquid sensing should operate is measured and marked off on the opposite side of the ribbon cable to the common positive wire.

The ribbon cable should now be placed flat on a suitable cutting board and a steel ruler placed on the cable so that it marks the angle between the first sensor wire and the point marked on the opposite side of the cable. A sharp knife should be used to

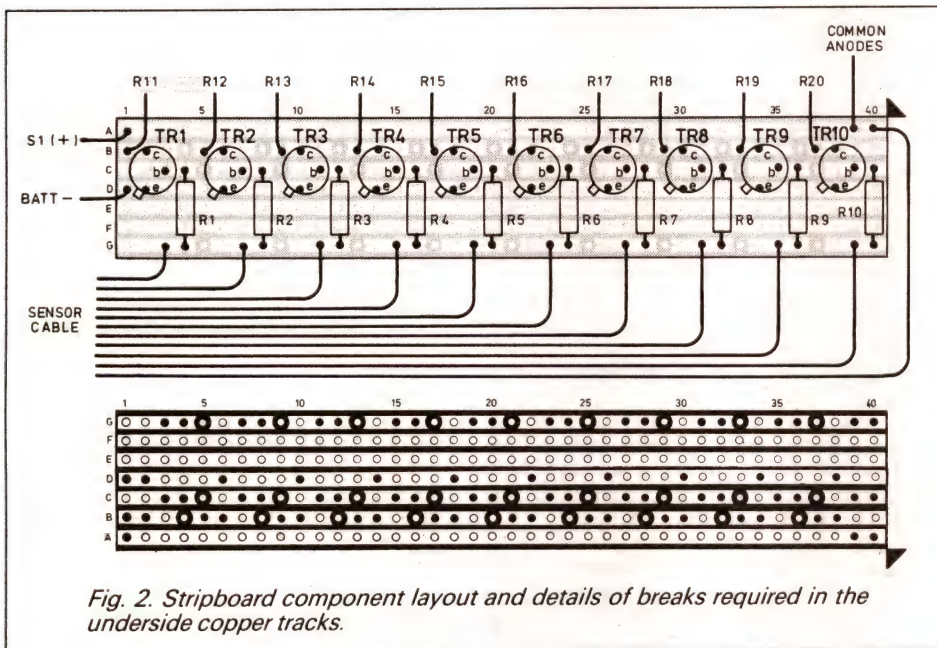


Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks.

COMPONENTS

Resistors

R1-R10 47 (10 off)
R11-R20 270 (10 off)
All 0.25W 5% carbon

Semiconductors

D1-D10 10-way l.e.d. display array
TR1-TR10 BC109 (or any npn signal transistor)

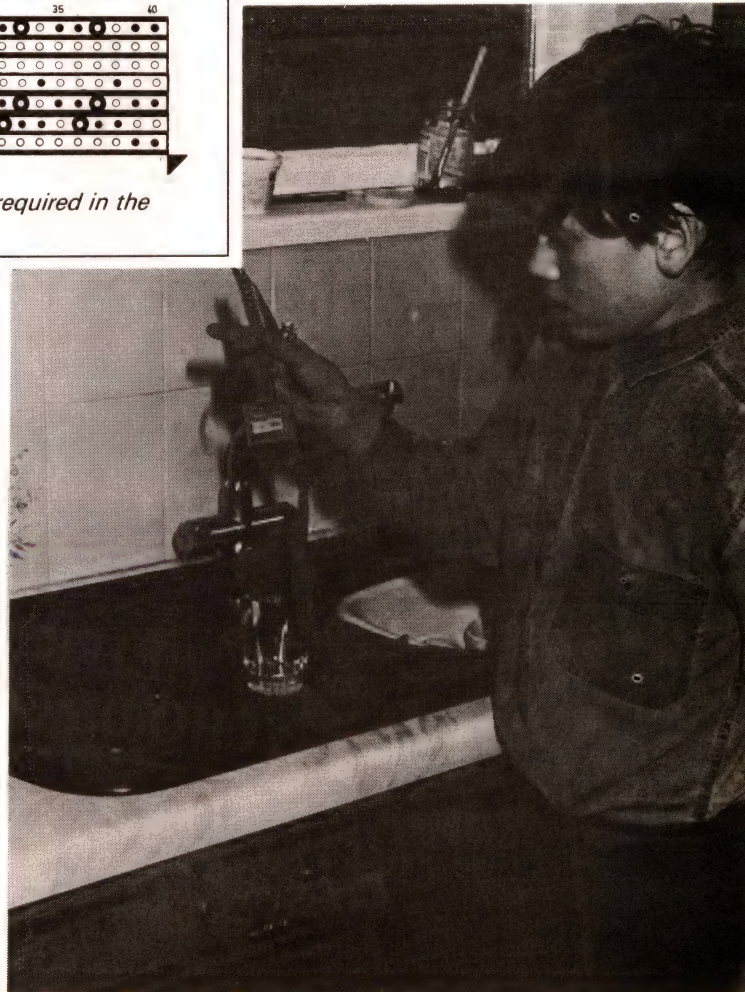
Miscellaneous

S1 S.P.S.T. push-to-make switch
B1 PP9 battery and connector
Stripboard, size 7 strips x 40 holes (1 off), 16 strips x 14 holes (1 off); 11-core ribbon cable (see text); plastic case, size 115mm x 75mm x 45mm; 4 x long bolts and 12 nuts.

Approx cost
guidance only

£10

See
SHOP
TALK
Page





cut the ribbon cable so that the end of the wire is cut at an angle as shown in Fig.3. It is not necessary to strip the wires at this end of the cable, since the wire bared by the cutting action will be sufficient to enable a current to flow.

The other end of the sensor cable should then be prepared by cutting, stripping and solder "tinning" the ends of the wires in the ribbon cable to connect at the points shown in Fig.2. The battery connections can also be made at this time with the negative connection of the battery connector lead soldered to the point shown as Batt - in Fig.2.

The positive wire of the battery connector should be connected to one of the terminals on switch S1 and a suitable piece of flexible insulated wire should be connected between the second terminal of S1 and the point marked plus (+) on Fig.2. Once these connections have been made the stripboard should be put to one side while the display stripboard is completed.

DISPLAY BOARD

The display for this project is a 10-segment bar l.e.d. array. The board needed to hold this display, and its associated series resistors, is made from a piece of stripboard which is 16 strips by 14 holes in size. The component layout and details of breaks required in the underside copper tracks as shown in Fig.4.

In order to mount the display board on the lid of the case which houses this project it is necessary to drill four mounting holes, in the positions shown in Fig.4. Once the stripboard has been cut the correct size then these should be drilled using a 4mm. drill bit. Once the stripboard has been prepared the resistors (R11 to R20) should be soldered in the appropriate places.

Although the 10 - segment bar l.e.d. display used in this project can be directly mounted onto the stripboard, fault finding will be made easier if this unit is mounted in a carrier in the same way as is used for integrated circuits. The easiest way to make a carrier of the type suitable for mounting the display is to obtain a 25 - way, single-in-line socket strip and cut it to give two 10-way strips. These are then inserted into the appropriate holes in the stripboard and soldered in the normal way. Care should be taken to ensure that both of the socket strips are mounted with their pins towards the same edge of the stripboard.

The next task in the completion of the display board is to connect a suitable length of 11-core ribbon cable, with the ends previously stripped and tinned to the positions shown in Fig.4. The final wiring task is to make sure that all of the common positive connections of the display (those on the opposite side of the display to the resistors) are connected together.

Although this can be done by means of individual wires inserted through the holes in the stripboard from the component side and soldered into place, the easiest method of accomplishing this task is to take a piece of single strand bare wire and solder it di-

rectly across the display carrier pins, which are on the side of the display which is opposite to the resistors, directly on the track side of the stripboard.

The ends of the ribbon cable used to connect the display board to the main driver board can now be stripped, tinned and soldered into place in the positions shown in Fig.4. The other ends of the cable should be cut to the correct lengths, stripped and tinned ready for termination on the main driver board. It is however advisable to delay connection of the display board to the main board until after the display board has been tested.

TESTING - DISPLAY BOARD

Fault finding on the completed project should commence with the Display Board since a fully working display board will enable testing of the main circuit board to be carried out with greater ease.

The Display Board is very simple to test, since all that is necessary to do this is to connect the end of the ribbon cable wire connected the common positive connections of the display, to the positive terminal of a 9V battery and then touch the end of each of the other wires in turn to the negative terminal of the battery. When each of the individual wires are connected in this manner the appropriate l.e.d. should be illuminated.

There is actually very little that can go wrong with the display board and the likely cause of any fault which might occur can be easily diagnosed by considering the pattern of which l.e.d.s do not illuminate when tested in this manner. If none of the l.e.d.s are illuminated then the most likely cause of the fault, assuming that the battery is sound, is that the common positive wire is not correctly connected to the stripboard or that the display has been inserted onto the stripboard or the connecting sockets the wrong way around.

If the l.e.d.s illuminate in sequence up to a certain point and then cease to function

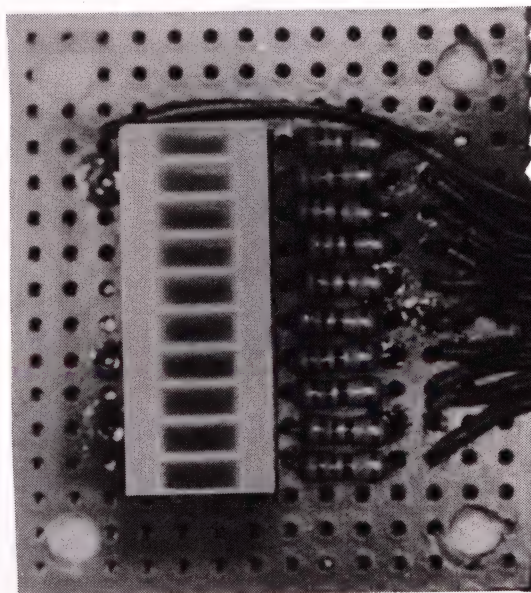
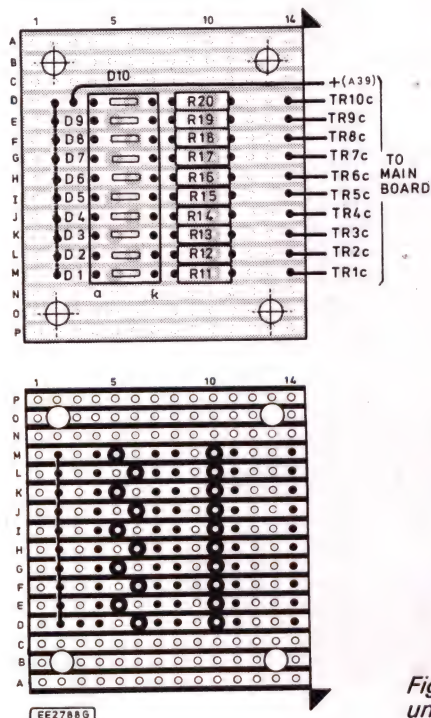


Fig. 4. (left). Stripboard component layout and details of breaks required in the underside copper tracks. Note the common anode link wire connection across the tracks. The completed display board is shown above.

after a specific point then the most likely cause is that the wire connecting the common anodes of the display has become open circuit at some point. In this case the cause of the problem will be found to be between the first l.e.d. which does not light and the last l.e.d. which does. The connection between these points should therefore be carefully checked to ensure that there are no breaks in the connecting wire.

If certain of the l.e.d.s illuminate but the others do not do so in a random pattern, then it will be necessary to check the connections throughout the circuit through each of the l.e.d.s which do not illuminate. Testing and fault finding should be done in a logical manner, starting with a resistance check along the wire in the ribbon cable associated with that particular l.e.d.

If this test proves that there is a complete circuit along the connecting cable then the next stage is to check the resistance between the point of termination on the cable on the stripboard and the nearest end of the appropriate series resistor. This is followed by a check on the actual resistance of the series resistor (which should be within + or - 20% of the stated value).

The next stage is to check the connection between the end of the series resistor and the cathode (k) of the l.e.d. in the bar display. If a break in continuity is discovered between any of these points, then the track associated with the connections and the associated soldered joints should be checked as should the soldering of the joint at the anode(a) of the l.e.d. which does not illuminate.

The integrity of the l.e.d. can also be checked by using the resistance setting of a multimeter. A sound l.e.d. should give a high resistance reading when the probes are connected with the polarity of the probes one way round and low resistance when the polarity of the test probes is reversed. (The precise polarity giving each of these two readings will depend upon the way in which the resistance measuring circuitry of the test meter has been constructed.)

Once a fully working display has been obtained then the ribbon cable from the display board should be connected to the Main Board in the positions shown in Fig.2. It is then possible to test the complete project.

Once a fully working display has been obtained then the ribbon cable from the display board should be connected to the Main Board in the positions shown in Fig.2. It is then possible to test the complete project.

FINAL TESTING

The easiest method of testing the completed project is to lower the end of the sensor cable into a glass of water, whilst operating switch S1. As each of the cores of the sensor wire are submerged in the water then each of the l.e.d.s in the display should progressively illuminate.

As the number of illuminated l.e.d.s increases it is possible that there may be some fluctuation in the brightness of the display but this is not significant. It is, however, important to check that each l.e.d. is turned on in turn, that no two l.e.d.s come on at the same time and that, when the sensor cable is completely immersed in the water, all of the l.e.d.s are illuminated.



The completed unit showing the display board mounted on the lid and the driver board positioned diagonally to allow room for the battery.

LIGHTING UP

The most likely fault to be encountered in this project is that one or more of the l.e.d.s does not illuminate as required. As all of the transistor driver circuits are identical then the same fault finding technique can be used for each of the l.e.d.s.

Before investigating the individual driver circuits in detail it is advisable to look at the pattern of which l.e.d.s light up and which do not, to see if any pattern emerges. If, when the sensor cable is inserted into the water, the first few l.e.d.s do not light up but the circuit then appears to be working after the cable has been immersed up to a certain level then, assuming that the display has tested out correctly, the most likely cause is that there is a break in the connections somewhere along the common negative track of the stripboard.

This can be most easily checked by connecting the multimeter, set to read 9V d.c. potential difference, so that the positive meter lead is connected to the connection to the battery positive wire at S1. The negative lead of the test meter should then be connected to each of the emitters of the transistors (TR1 to TR10) in turn and a note made of whether the battery voltage is measurable or not at each emitter.

If at any point the battery voltage ceases to be measured then a careful investigation should be made at the point at which the voltage was last measured and the first point at which the voltage was missing. The likely cause of any problems of this nature will be a break in the track or a "dry" soldered joint.

TEST DRIVE

Testing of each individual circuit will be made easier if switch S1 is shorted out by temporarily soldering both of the connecting tags together since this saves the necessity of having to operate S1 every time you wish to make a test.

The next stage of fault finding in this circuit is to make a temporary short circuit between the emitter and collector of the transistor associated with any non working l.e.d. using a piece of wire. If this causes the l.e.d. associated with the transistor to be illuminated then this indicates that the fault lies on the main circuit board and not on the display board.

If this test fails to cause the l.e.d. to il-

luminate then the complete circuit between collector of the transistor and the common positive connection to the anode of the display l.e.d. should be carefully investigated, using the resistance setting of the multimeter. If all is well in the circuit through the l.e.d. and its series resistor to the battery positive connection and the negative connection to the emitter is also correct then it will be necessary to check the continuity of the circuit from the sensor cable, through the associated resistor to the base of the transistor.

Connect a test meter, set to the resistance range, to the cut end of the sensor cable associated with the non working circuit and check through the circuit from there to the base of the transistor. It should be possible to measure a very low resistance (typically 47 ohms) between these two points. Taking the meter probe from the base to the emitter should give a similar reading. If a resistance significantly higher than this is measurable then this would indicate that the likely faults are dry solder joints or that the base resistor is "off spec" and should be replaced.

The final check required is to make a temporary connection between any battery positive connection (such as the wires connected to S1) and the end of the associated base resistor *furthest away from the transistor*. **It is very important to make sure that the connection is made to the correct side of the dropping resistor since a direct connection between the positive battery voltage and the base of the transistor will cause certain destruction of it.**

The effect of this on the display should be observed. If the display diode does illuminate, this will indicate that the fault lies in the sensor cable. If the l.e.d. does not light up then the voltage between the base and the emitter of the associated transistor should be measured, with the connection between the resistor and the battery positive still in place.

This should be approximately 0.7 volts. If 0 volts is measurable at this point then this would indicate the possibility of a short circuit between the base and emitter of the transistor. The most likely cause of this is a blobbed solder joint between the base and the emitter of the transistor.

If a voltage of 0.7 volts or more is measurable between the base or emitter of the transistor and the associated display



diode is not illuminated, but the display diode illuminates when a temporary short circuit is made between the collector and the emitter of the transistor then the most likely cause is that the transistor is defective. It should therefore be replaced with another transistor and the circuit checked to ensure that it operates correctly.

The only other form of fault that you are likely to encounter in this project is where two or more l.e.d.s come on at the same time. There is really only one cause of this fault which is that there is an incomplete tract break between two adjacent circuits.

CASE

The circuit, once completed and tested, should ideally be mounted in a case. The first stage is to allocate a position for the 10 - bar l.e.d. display and switch S1. When

doing this care must be taken to ensure that the body of the switch and the display board will not foul the main stripboard when it is inserted into the case with the lid in position.

Once the position of S1 and the display have been allocated then these positions should be carefully marked onto the lid of the case. The hole for S1 can be drilled using an appropriate sized drill bit but the hole for the display is slightly more difficult to construct, because it will require the cutting of a rectangular hole in the case lid.

The easiest way to accomplish this is to carefully draw the required shape and drill a series of small holes around the inside of the marked rectangle, sufficiently close to each other so that the connecting plastic may be cut away using cutters. When all of the pieces of plastic connecting the drilled holes have been removed, a file is used to carefully finish the hole to the required shape.

Once the hole for the display has been shaped in the case lid then the display board should be offered into position and the location of the four mounting holes, previously drilled in the display board should be marked on the under side of the case. These holes should then be drilled through the case front using a 4mm drill bit. If desired, these may be counter sunk from the front of the case, to enable countersunk bolts to be used for retaining the display board.

The final cutting operation involving the case is to carefully cut out a slot, in both the case body and in the lip of the lid, through which the sensor cable can protrude when the case lid is secured in place.

The case can now be lettered, using rub down lettering which is secured in place by

several layers of clear varnish, sufficient time being allowed between each coat for the previous application to thoroughly dry. Once the preparation of the case is completed then the case mounted components can then be installed in to the positions already prepared for them.

Although the mounting of the switch S1 is simple enough the method of mounting the display needs a little explanation. The display board is supported away from the case lid by means of four long bolts which are mounted in the holes already drilled in to the case lid for them. In order to achieve a satisfactory support for the board, whilst at the same time standing it away from the case lid itself, it is necessary for each bolt to be fitted with three nuts. One of these nuts is used to clamp the bolt firmly to the face of the case lid whilst the other two are used to position and clamp in place the display board.

The main driver board and battery should now be positioned in the case. Because of the fact that the main driver board is rather long it may be necessary to mount it inside the case in a diagonal position.

When positioning the battery and the driver board care should be taken to ensure that when the case lid is fitted neither S1 nor the display board will foul the battery of the main driver board.

IN USE

When using the Electronic Dipstick to measure the depth of liquid in a container, all that has to be done is to insert the sensor cable into the container of liquid until the end of the cable reaches the bottom and press switch S1. The depth of the liquid in the container is immediately indicated on the l.e.d. display.

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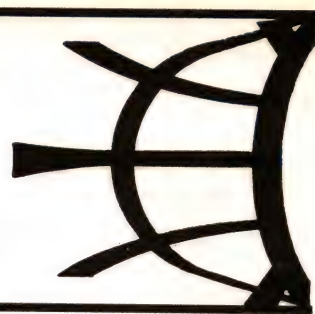
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REPORTING AMATEUR RADIO

Tony Smith G4FAL



WHAT DOES AMATEUR RADIO OFFER ME?

The revised edition of the DTI's booklet *"How to become a Radio Amateur"* contains an introductory question and answer section beginning with the question "What Does Amateur Radio Offer Me?" This is difficult to answer in a few words because there are so many things that can be said about such a wide-ranging hobby. The booklet makes a good attempt, however, and is worth repeating here:

"Amateur radio is unique in the freedom it allows you to develop and experiment with radio communication equipment. It can even enable you to communicate around the world.

"Radio amateurs may make contact with people in any country. Even language differences need not be a barrier by using Morse code and "Q" codes (these are three-letter codes which have the same meaning throughout the amateur radio world).

"Radio amateurs are often at the forefront of radio technology and increasingly they are able to use their home computers to combine computer technology and radio. By becoming a radio amateur you can prepare yourself for a world which is increasingly technology based. For example, you can experiment with antennas, television, RTTY (radio teletype), data (including computer controlled communications such as packet radio), satellite communications and, of course, short or long range voice or Morse code transmissions.

FRIENDSHIPS

"The hobby frequently leads to participants making lasting friendships both in the United Kingdom and worldwide. In this way it has proved to be a great asset to those who are housebound, or who find mobility a problem, because of the opportunity it provides to make friends.

"Many other amateurs are able to offer their services to the first aid organisations and even the police at public events during disaster relief operations at home and abroad. For most amateurs, however, it is just the sheer excitement of that chance contact with an individual hundreds or even thousands of miles away that is so absorbing."

There's even more to it than that, of course, and the publication goes on to give the bare bones of it all in terms of the rules and regulations. In the meantime, keep reading this column as I put the meat on the bones, illustrating what amateur radio is in practical terms and what it means to the individuals involved in it. There is no short answer to that original question!

The booklet is available free of charge from *Radio Amateur Licensing Unit, Post Office Counters Ltd, Chetwynd House, Chesterfield S49 1PF.*

FURTHER READING

For those interested in taking the radio amateurs' examination, the DTI recommends a short "further reading" list. This includes *"How to Improve Television and Radio Reception"*, available from Post Offices; *"The Radio Amateurs' Examination Manual"* (RSGB); *"A Guide to Amateur Radio"* (RSGB); *"Amateur Radio Operating Manual"* (RSGB); and a number of DTI Information sheets which expand on some of the information contained in the booklet.

These are: No. 1, Radio Amateur Licensing; No. 2, Amateur Service Allocation in the 50MHz (6 metre) and 70MHz (4 metre) Band; No. 3, Morse; No. 4, Amateur Radio Call Signs; No. 5, Amateur Radio Clubs and Societies; No. 6, Radio Amateurs' Examination; No. 7, New Amateur Radio Licence; No. 8, Radio Investigation Service District Offices; No. 9, CEPT Amateurs (UK Licensees); and No. 10, CEPT Amateurs (Visiting Licensees). These sheets can be obtained, free of charge, from *Radiocommunications Agency, Information and Library Service, Waterloo Bridge House, Waterloo Road, London SE1 8UA.*

USING THE BUREAU

The most used service of the Radio Society of Great Britain is its QSL Bureau, whereby members send and receive QSL cards worldwide at minimal cost, and non-members can receive cards from members on the same basis. The Society recently re-organised the bureau, which is now sited at RSGB headquarters.

Cards for distribution are sent by individual amateurs, in quantity, to Potters Bar. Here they are sorted and despatched in bulk to overseas bureaux, usually operated by member-societies of the International Amateur Radio Union, or to UK sub-bureaux organised by call-sign series.

Members and licensed non-members can send stamped addressed envelopes to the appropriate sub-bureau and these are returned filled with cards when the weight of cards "waiting" reaches the maximum covered by the pre-paid postage. Cards for amateurs who have not lodged envelopes are kept for three months and then destroyed. The full facilities of the bureau are available to both transmitting and receiving members of the society, although reception reports relating to short-wave broadcasting stations cannot be accepted.

Although the bureau represents the cheapest way of exchanging QSL cards, it is not the fastest. By the time a card gets through the different stages of its journey, and its reply returns by the same route, some six to nine months can elapse. Some amateurs take a long time to send out cards and I sometimes receive QSLs for contacts I had four or five years ago!

The moral of all this is that those who desperately want a particular card should consider sending their own direct to the other station, enclosing an s.a.e., or two international reply coupons, to cover the cost of return postage. This won't guarantee a reply but it improves the chance of getting one quite considerably.

CALL-SIGN CONFUSION

For years, the UK call-sign system has been fairly easy to follow. The letter *G* signifies a British station and a second letter indicates a region other than England, thus *GW* - Wales; *GM* - Scotland; *GI* - Northern Ireland; *GU* - Guernsey; *GJ* - Jersey; and *GD* - Isle of Man.

A special series of call-signs using the prefix *GB* has been allocated to "special event" demonstration stations, which have been permitted to put unlicensed operators (eg, members of the public) "on-the-air", under supervision, to send simple greetings to other stations in the UK, the USA, Canada, the Falklands, and Pitcairn Island.

New regulations now permit licensed club stations to use the greetings message facility without the need for a special GB call-sign, but they have to modify their existing call to indicate when they are using the facility. A club station normally located in England, with a *G* prefix, would therefore become *GX*; Wales (normally *GW*) *GC*; Scotland (*GM*) *GS*; Northern Ireland (*GI*) *GN*; Guernsey (*GU*) *GP*; Jersey (*GJ*) *GH*; and Isle of Man (*GD*) *GT*; reverting to its regular call-sign when returning to normal amateur operation.

Even more confusing are the DTI's proposals for a new series of calls when either the remaining class *B* (*G7*s to be followed by *G5*s) or class *A* (*G0*) series run out. It is then proposed to abandon all further *G*-allocations and start a new series of calls beginning with the letter *M*.

A second letter will indicate the class of licence. Possibly *MA-MJ* prefixes will denote class *A*, and *MK-MZ* class *B*, although *MB* could be reserved for special event stations and *MC* for clubs. A number would indicate the region where the station is located; England - 2; Scotland - 3; Wales - 4; Northern Ireland - 5; Isle of Man - 6; Jersey - 7; Guernsey - 8. For example, *MA2AAA* would be a class *A* station in England, but if it moved to Wales it would become *MA4AAA*.

To add to the confusion, call-signs for the new Novice licences will probably start with the figure 2, with the series running from *2A1AAA* to *2Z9ZZZ*. The second symbol (letter) would again indicate the licence class (Novice *A* or Novice *B*), and the third symbol would again be a number, indicating the region where the station is located.

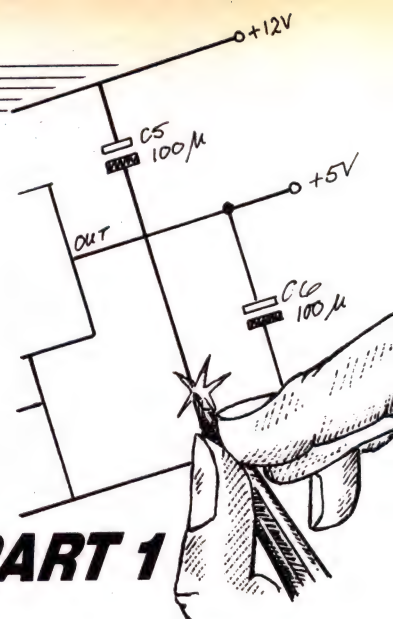
Teach In '91

DESIGN YOUR OWN CIRCUITS

Getting started

MIKE TOOLEY BA

PART 1



This ten part series which is designed for the beginner and experienced reader alike, aims to dispell some of the mystique associated with the design of electronic circuits. It shows how even the relative newcomer to electronics can, with the right approach, design and realise quite complex circuits.

In this first part we introduce the series, describe the tools and test equipment you will require to follow the series, outline some basic concepts and get to grips with practical aspects of the design of electronic power supplies. Our companion project deals with the construction of a Versatile Bench Power Supply.

introduced where it is directly relevant to a particular topic. By this means, we shall be able to get to grips with some fairly complex circuits at an early stage.

Readers

At this stage, you may perhaps be forgiven for wondering just what it is that we have assumed about you! Essentially, you should be able to:

1. Identify common electronic components and recognise their symbols.
2. Understand commonly used component markings and colour codes.
3. Use a multi-range meter to make voltage, current, and resistance measurements.
4. Know the basic electrical units and the symbols used to represent them.
5. Make use of multiples and sub-multiples and recognise the prefixes used to denote them.
6. Understand basic electrical concepts such as e.m.f., potential difference, and current flow.
7. Read and understand simple circuit diagrams (if you can cope with the majority of circuits published in E.E. then you will have little difficulty with any of those which will appear within this series).
8. Use a soldering iron and a range of small electronic tools.

If you are doubtful about topics 1 to 7, then it would be well worth investing in a copy of the *Everyday Electronics Data Book* (available at £8.95 from the *Everyday Electronics Direct Book Service*). This book contains all of the preliminary information that is required to follow the series and also contains numerous examples, hints and tips for the budding electronic circuit designer.

Tools and test equipment

In order to follow the series (and to build the modules and projects which we describe) you will need very little in the way of tools and test equipment. Most of the items will already be available but if this is not the case most of E.E.'s regular advertisers should be able to help. The following list should give readers some idea of what is required:

- ★ a soldering iron (15W to 20W) with a supply of multicore solder
- ★ a multi-range meter (preferably digital) with test leads
- ★ a set of small electronic tools including

Introduction

Welcome to *Design Your Own Circuits*, a new and exciting series which has been designed especially for *Everyday Electronics* readers. The series deals with a topic which we feel almost every reader will wish to get to grips with and differs in a number of important respects from any of the previous "educational" features in this magazine. The series will lead you gently through all of the stages in designing a wide range of electronic circuits "from scratch". There is no "magic" in this; just logical thinking coupled with a basic understanding of electronic circuits and components!

In order to provide readers with an opportunity to develop their skills further, each part will incorporate a **design problem** together with a complete **practical project**. The problems have been included so that readers can test their knowledge and understanding as they progress through the series and, although "model answers" will be provided they should not be regarded as the ultimate solution. Readers should not therefore be discouraged if they find that their own answers differ markedly from

those presented. In addition to the design problems, the text for each part will be interspersed with questions so that readers can rather more frequently check their understanding.

Practical projects have been included so that readers can follow the complete process of design, assembly, construction, testing and evaluation. Each project will be accompanied by a number of suggested modifications and improvements so that each one can be "customised" to suit the needs of individual readers. The practical projects have been designed to stand on their own as complete items of equipment in their own right and thus should appeal to those readers who may not necessarily be following the series.

Our overall aim in this series has been that of attempting to foster an intuitive approach to design. Such an approach does not rely on the mastery of complex mathematical formulae rather it is based upon an understanding of the behaviour of common electronic components and the application of a few basic principles. To this end, the approach will be somewhat unorthodox in that theory will only be

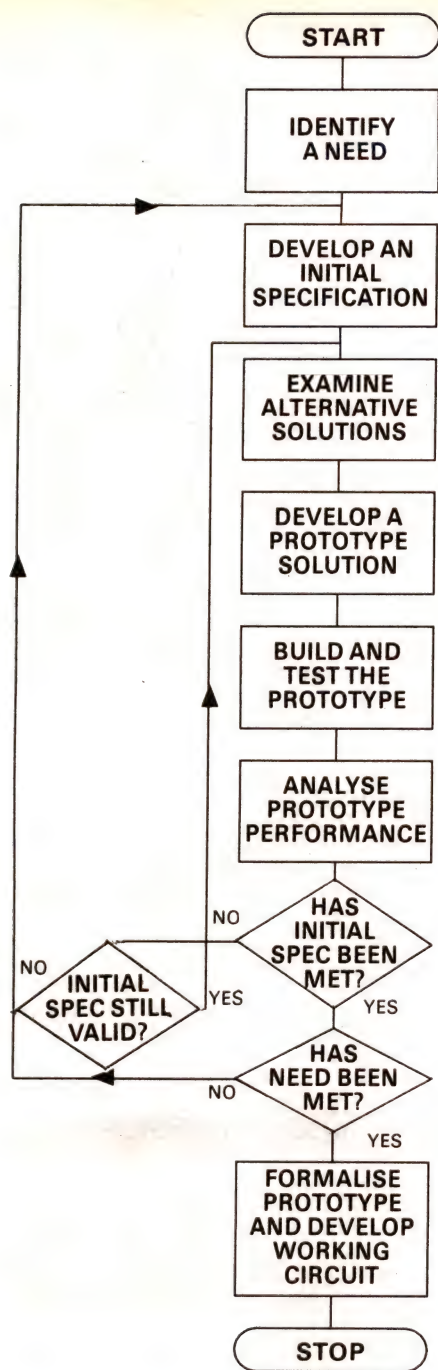


Fig. 1.1. Basic steps in the design process

side cutters, pliers and screwdrivers, a small drill (either a hand-drill or mini-electric drill), a set of drill bits (1mm to 10mm), and a trimming knife

★ a desoldering pump

The following additional items will be found useful in conjunction with our companion projects:

- ★ a small hacksaw
- ★ a set of small hand files
- ★ a tension file
- ★ a steel rule, scribe and centre-punch

Series summary

Each part of the series deals with a different topic area. In Part One, we start with a general introduction to the principles of circuit design before moving on to deal with the design of power supplies for use in a variety of electronic equipment. Our design problem features a simple oscilloscope voltage calibrator whilst our accom-

panying practical project involves the construction of a versatile bench power supply.

Parts Two and Three deal with amplifiers (transistor and operational amplifiers are introduced in Part Two whilst Part Three is largely devoted to consumer integrated circuits and power amplifiers). A number of important concepts are developed in these two parts including gain, phase-shift, feedback, noise and distortion. The design problems and projects include a microphone pre-amplifier, a guitar amplifier, an intercom system, and a bench amplifier/signal tracer.

Oscillator design is covered in Part Four. We shall be dealing with sinusoidal (both a.f. and r.f.) and square wave oscillator circuits and our project features a signal generator with sine, square and triangular wave outputs.

Part Five introduces the world of digital electronics and describes the use of logic gates, monostable and bistable circuits, counters and shift registers. Our design problem is based on an intruder alarm.

Integrated circuit timers are featured in Part Six and the complementary project features a versatile pulse generator. Radio is introduced in Part Seven whilst Part Eight deals with power control. Projects include an r.f. signal generator (with internal and external modulation) and a disco lights controller.

Part Nine is devoted to optoelectronics and features the use of photo-emitters and photo-detectors. Our design problem is based on an automatic porch light whilst the accompanying project shows readers how to design and construct an optical communications link. Finally, Part Ten (entitled *What Next?*) aims to round-off the series with feedback from readers as well as providing some "food for thought" for further work.

The design process

The process of design, whether it be in electronics or in any other field, is, of necessity a logical undertaking in which there is nonetheless plenty of scope for flair and imagination. As with many other pursuits, the sequence of events is crucial. Fig. 1.1 shows the basic steps within the design process. The first stage (and arguably the most important) is that of identifying a need. Without this, the rest of the process is meaningless. Indeed, if a need cannot be identified at an early stage, there is little point in progressing further.

The need for an electronic circuit may arise from a variety of sources; from a purely personal requirement to widespread commercial demand. Examples in the former category could include a requirement to produce a baby alarm consequent on the arrival of a brand new member of the family. Here, the designer is likely to be the "end-user".

In the commercial category, however, the end-user is not the designer and appropriate market research will be an essential pre-requisite when carrying out an analysis of needs. In addition, many commercial products are "test marketed" before large-scale production starts. This test marketing is instrumental in not only determining the size of the potential market but also yielding some very useful information about the end-user.

A commercial decision concerning the viability of a product will not usually be taken until both market research and test marketing has taken place. Financial backing may be dependent upon both of these

elements as well as the viability of the overall "business plan" produced by an organisation.

Modular approach

A modular approach to circuit design offers a number of advantages, not the least of which is that it readily permit the assembly of quite complex equipment from a number of more easily assembled and tested sub-circuits. A further significant advantage (and one which is often forgotten at the early stages) is that a modular approach readily permits the replacement and upgrading of parts of the equipment as needs dictate.

A module may comprise as few as half a dozen active devices or perhaps as many as fifty or more. Each module should have a defined function and will probably be associated with one (or more) blocks within the functional block schematic of the equipment. The interface from one module to other modules within the equipment should be clearly defined in terms of the signals and voltage levels present. As far as possible, these should be standardised so that modules can be made fully interchangeable.

Throughout this series we have attempted to standardise on the range of connectors, signals and supply voltages so that, not only are the individual circuit modules compatible with one another but also those which provide similar functions are interchangeable.

A number of the circuits described in our series will be presented as "modules". A printed circuit layout (together with a component layout diagram and detailed component list) will be provided for each and, whilst each is a complete working circuit in its own right, modules may be interconnected to realise a number of more complex functional circuits. Our modules can thus be thought of as constituting the basic "building blocks" of a large number of practical electronic circuits.

Hence, for example, it would be possible to put together a complete audio amplifier system using standard modules taken from several parts of the series. The power supply module (a dual regulated supply providing $\pm 15V$ rails at 1A) could be taken from Part One, a pre-amplifier/tone control module taken from Part Two, and a 10W high-quality output stage taken from Part Three.

A cumulative index of modules (together with brief specifications) will accompany each part of the series. This index will provide readers with a means of matching their requirements with circuits which have previously appeared in the series and which are thus available "off the shelf".

Specifications

At the outset, it is vital to form an initial specification for a circuit. This is an essential pre-requisite in any design project. Indeed, to start without any fixed idea of what is actually required is foolhardy to say the least!

The initial specification should be regarded as a target. In practice, it may not be possible to realise this initial specification for a whole host of reasons hence the initial specification should not be so fanciful that it is impossible to achieve.

Getting the initial specification right is an art in itself; if the specification is made too exacting it may be impossible to achieve, if made too undemanding there may be little incentive to improve on known technology.

Where a requirement is particularly novel, a little "brainstorming" can be useful when forming a specification. Try to think laterally and avoid falling into the trap of merely adapting an existing solution; a balance between lateral and traditional thinking is essential. Indeed, to go too far along either road at the expense of the other can be detrimental to the development of one's skills as a designer.

Lateral thinking

At this point, it is probably worth spending a little time to explain just what we mean by the term "lateral thinking". Lateral thinking involves dismissing (at least initially) traditional methods of solving a problem. As far as possible, one should abandon the "tried and tested" approach and think "around" the problem in a radical manner.

As an example, consider a requirement for a highly accurate 1MHz reference clock signal for use in an item of test equipment. Using the traditional approach, we might consider using the output of a highly stable crystal oscillator. In order to achieve the requisite stability, we would probably have to place the crystal and associated oscillator circuitry in a carefully temperature controlled environment (a "crystal oven"). Furthermore, the quartz crystal itself would have to be a very high quality and accurate component. Using this approach, we could hope to produce an arrangement which offers a frequency accuracy of around ± 20 parts-per-million.

Lateral thinking may, however, result in a totally different (and cost-effective) approach to this problem. Rather than adopt a circuit which is based on a locally generated signal, the "lateral thinker" may decide to make use of a broadcast standard frequency signal. This signal would be used as a "reference" to which a locally generated signal can be "locked". The "off-air" signal is simply received, amplified and squared before it is applied as the reference signal within a phase-locked loop

(PLL). As a bonus, the frequency accuracy of such an arrangement is several orders of magnitude greater than that which can be obtained by the conventional "ovened-crystal" approach and the long-term stability is also greatly improved.

The traditional approach to the problem is illustrated in Fig. 1.2a whilst Fig. 1.2b shows the arrangement which results from lateral thinking. The arrangement of Fig. 1.2b is more complex than that in Fig. 1.2a however very considerable savings are achieved since individual component tolerances can be very much less stringent and there would be no need for a closely temperature controlled environment.

A representative breakdown in cost for the two approaches is as follows:

Traditional:

Crystal (close tolerance)	£8.00
Oscillator circuitry	£3.00
Buffer/amplifier	£3.00
Voltage regulator circuit	£2.00
Temperature controller	£8.00
Thermally sealed enclosure	£5.00
PCB etc	£5.00
Approx. total component cost:	£34.00

Lateral approach:

Ferrite antenna	£2.00
RF filter	£10.00
RF amplifier/squarer	£2.00
Divider stage	£2.00
PLL oscillator	£3.00
PCB etc	£5.00
Approx. total component cost:	£24.00

This example has been designed to highlight the differences in approach and, whereas it shows clearly the cost-effectiveness and advantages of the solution achieved by lateral thinking, there are some disadvantages (notably the fact that an "off-air" signal may not always be available!). This again highlights the importance of starting out with a meaningful specification; we should have specified that the equipment will operate in any normal environment (including a basement) – clearly this may not always be the case!

In practice, we may wish to adopt a compromise approach which benefits from the advantages of both techniques. In such an event, we could capitalise on the very significant improvement in accuracy and long-term stability offered by an "off-air"

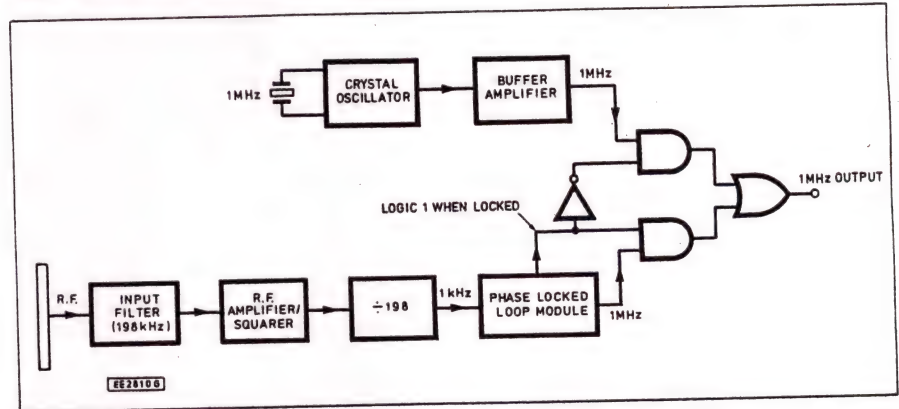


Fig. 1.3 A combined solution

reference (typically 1 part in 10^{10} for a Droitwich locked standard) whilst being able to revert to the inherent reliability of a locally generated signal whenever the off-air standard is unavailable.

The final solution might run along the lines shown in Fig. 1.3. By combining the "tried and tested" approach with the innovative approach we have produced a solution which offers very significant advantages over either method used alone.

Data

Most electronics enthusiasts are avid collectors of data. Anyone involved within the design of electronic circuits will find that access to a bank of data is essential in order to make effective use of the huge variety of electronic components currently available. Magazine articles and application notes (published by component manufacturers) are an excellent source of ideas and are likely to contain numerous tested circuits. Would-be designers should not feel guilty about "borrowing" ideas from other people as one can learn a lot from others' ideas and there is absolutely no point in "re-inventing the wheel".

Sources of data available to the electronics enthusiast include manufacturers' data sheets and data books, suppliers' catalogues, magazine articles, application notes, textbooks and technical reports. At the outset it is worth organising a data library into related topics using a filing cabinet or just simply a collection of cardboard boxes fitted with dividers.

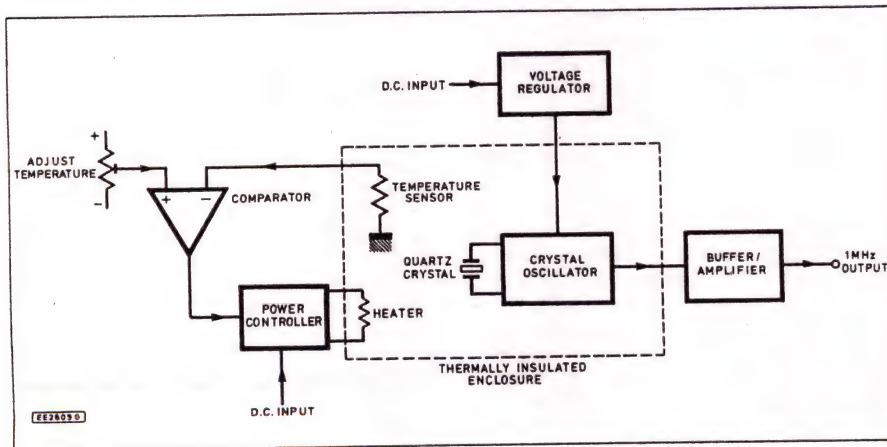
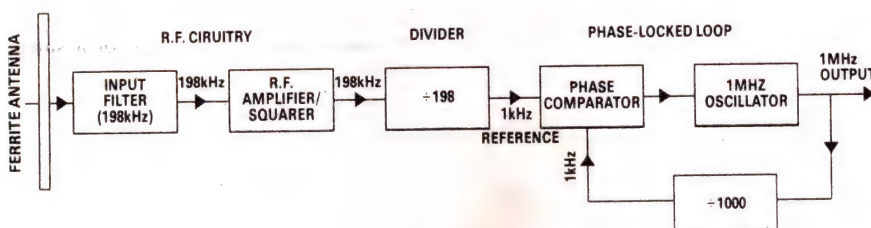


Fig. 1.2a Traditional approach to providing the highly stable 1MHz signal

Fig. 1.2b "Lateral thinking" approach based on a PLL and off-air standard



Textbooks and data books can be stored in a conventional bookshelf along with magazines (preferably in binders) and the larger catalogues.

Sources of data which can be particularly recommended include:

The *Maplin Buyer's Guide to Electronic Components*. This excellent publication is more than just a catalogue since it contains a vast amount of information on just about every common type of electronic component. Several thousand semiconductors are listed and the section of the catalogue devoted to integrated circuits contains pin-connecting information and numerous application circuits.

Everyday Electronics. This monthly magazine never fails to provide a wide variety of electronic projects and educational features which are suited both to the beginner and the more experienced enthusiast.

The *Modern Amateur Electronics Manual*. This enormous reference work aims to provide a practical reference to modern electronic technology. It is a loose-leaf publication (in several volumes) with regular updating supplements which are published approximately bi-monthly.

Data sheets

All manufacturers provide data sheets (often free) and data books (usually available at moderate cost) which cover their products. These can be invaluable to the designer since they provide a great deal of useful information and, in particular, give some indication of the maximum and minimum operational parameters for a particular device. The designer is thus made aware of the limits within which he must work when designing a circuit based on the device in question.

Many data sheets (and data books) contain typical application circuits. Some manufacturers also provide detailed application notes which are written by their own applications design staff. These can make very useful reading since they give a considerable insight into the thought process of other designers and can sometimes point the way to some really novel applications.

As an example of using data sheets (and since this first part of our series is devoted to power supplies) it is worth taking a look at the first four pages of the National Semiconductor data sheet for the LM723 voltage regulator shown in Fig. 1.4.

The format of this data sheet is typical of that used by nearly every semiconductor manufacturer and comprises a general description of the device, internal schematic (circuit diagram) and pin connections for the device, absolute maximum ratings, electrical characteristics, derating curves, typical performance characteristics, and typical applications circuits.

Readers should spend a little time reading through the data sheet but should not be too worried if very little of it makes sense initially! Much of the data will be of relatively little significance in most applications and it is certainly not essential to understand everything on the data sheet to put the LM723 to good use.

Question 1: Use the National Semiconductor data sheets for the LM723 to determine the following:

- maximum continuous input voltage
- maximum operating temperature for an LM723C
- positive input connection for the dual-in-line version

- minimum input voltage
- minimum output voltage
- typical load regulation
- typical short-circuit current (at 25°C)
- typical short-circuit current (at 125°C)
- maximum power dissipation at 50°C for an LM723C in a TO5 package

Power Supplies

Having now set the scene (and hopefully whetted readers' appetites for what is to come!) we now get to grips with the first topic within our practical circuit design series; **Power Supplies**. Since every circuit that is not operated directly from a battery will require a power supply, this seems a very logical place to start!

The power supply is the hidden hero of every electronic circuit; we happily assume that it is there and doing its job. Rarely do we give it the attention that it really deserves.

In general a power supply should:

- provide the rated voltage of the circuit which it is to supply (within acceptable tolerance limits)
- provide current up to the rated maximum for the circuit which it is to supply (without the supply voltage falling outside the specified working range)
- maintain the rated output voltage (and current capability) over a range of conditions (e.g. ambient temperature, a.c. mains voltage variations, load circuit demand, etc)
- cope with short-circuit component failures which may arise within the circuit which it is to supply (and which may otherwise damage the power supply)
- have adjustable voltage and current limit (as required)

A typical power supply specification may run along the following lines:

Output voltage:	12V $\pm$ 5%
Maximum output/load current:	1A
Hum and noise:	less than 10mV
Regulation:	better than 2%
Output impedance:	less than 0.1 ohm
Input voltage:	220 to 240V a.c. 50Hz

Most of this should be reasonably self-explanatory. First we need to achieve an output voltage which is nominally 12V (but an output in the range 11.4V to 12.6V would be acceptable). The output voltage needs to be maintained within this range for load currents of up to 1A (note that the output voltage can be expected to fall as the load current increases).

There is residual hum (i.e. an a.c. signal component at mains or twice mains frequency) and noise (a random unwanted a.c. component) present on the output of every power supply. In practice this can be reduced to negligible proportions by regulation, smoothing and decoupling. We simply have to ensure that, in this case, the total amount of hum and noise superimposed on the d.c. output does not exceed 10mV r.m.s.

Regulation is a measure of how good the power supply is at maintaining its output voltage in the light of input voltage or load current variations. A regulation of 2% means simply that the output voltage should be maintained within 2% over the given range of a.c. input voltages (220V to 240V) and load current (zero to 1A). In practice (and since we may suffer from variations in line voltage and load current

at the same time) we may wish to quote two figures for regulation; one for line and one for load.

Question 2: What is the maximum permissible change in output voltage from the power supply if the mains voltage falls from 240V to 220V? (Hint: we would expect the output to change by no more than 2%)

Transformers

Arguably the most important (but often most neglected) component in any power supply is the transformer. This component is used to provide both isolation from the a.c. mains supply (ensuring that the equipment which is being powered is not connected directly to either of the supply lines, line and neutral) and a means of stepping down (or stepping up) the mains supply voltage to a value which is within the range acceptable to the rectifying and stabilising stages which follow.

Transformers must be adequately rated for the service which they are required to perform. Not only does this mean the selection of the correct primary and secondary voltages but also consideration of the current which is drawn from the secondary. Transformer manufacturers often quote a "VA" rating for their components. This is simply the total secondary load, which can be determined by adding together the products of voltage, V, and current, A, in each secondary winding present.

If this is beginning to sound a little complex, consider the case of a mains transformer with two identical secondary windings each rated at 6V 0.5A. Its nominal VA rating would then be 6VA.

Question 3: A transformer has two secondary windings each rated at 12V 2.5A. Determine its VA rating.

Fortunately, most transformer manufacturers provide components which, within a particular VA rating, have identical size but different values of secondary voltage and current. Hence, a popular 6VA rated transformer for printed circuit board mounting is available with the following secondary windings:

2 $\times$ 6V at 0.5A
2 $\times$ 9V at 0.33A
2 $\times$ 12V at 0.25A
2 $\times$ 15V at 0.2A
2 $\times$ 20V at 0.15A

The range of secondary voltages and the provision of two separate secondary windings provides the designer with considerable scope. In addition, since the primary will generally also have two separate windings (each rated at 120V), this will provide even greater flexibility.

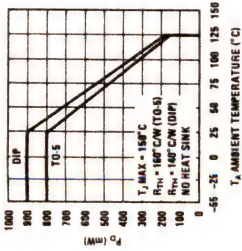
Fig. 1.5 shows the range of possibilities for the 6VA transformer with two 6V 0.5A secondary windings, which we met earlier as shown in Fig. 1.5. In Fig. 1.5a, the primary windings are connected in series to operate on a 240V a.c. supply whilst the two secondary windings (also connected in series) are wired to produce an a.c. output of 12V at 0.5A. The transformer in Fig. 1.5b is again connected for 240V a.c. operation however the parallel connected secondaries produce an output of 6V at 1A (i.e. double the current rating of a single secondary winding).

In Fig. 1.5c the primary windings have been parallel connected for 120V (rather than 240V) operation. The two secondary windings have been series connected to provide an output of 12V at 0.5A. Finally, the transformer in Fig. 1.5d has both primary and secondary windings connected

maximum power ratings

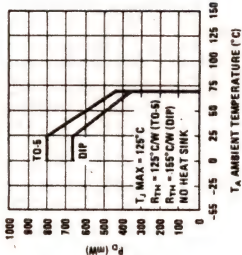
LM723

Power Dissipation vs Ambient Temperature



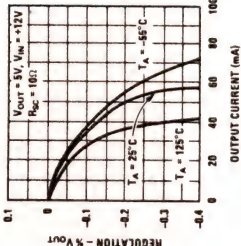
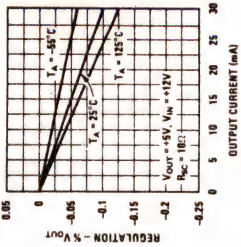
LM723C

Power Dissipation vs Ambient Temperature

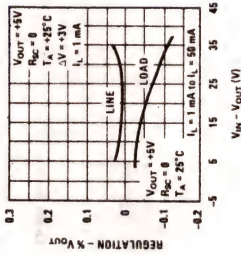


typical performance characteristics

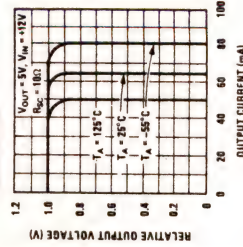
Load Regulation Characteristics with Current Limiting



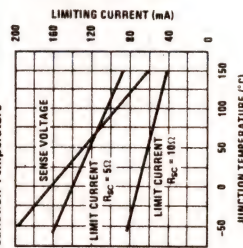
Load & Line Regulation vs Input-Output Voltage Differential



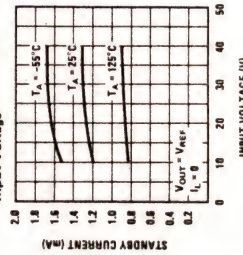
Current Limiting Characteristics



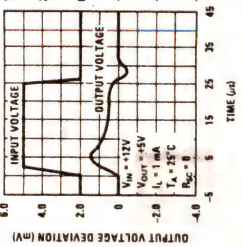
Current Limiting Characteristics vs Junction Temperature



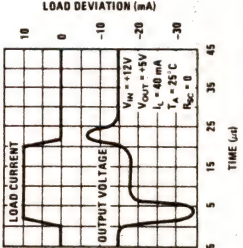
Standby Current Drain vs Input Voltage



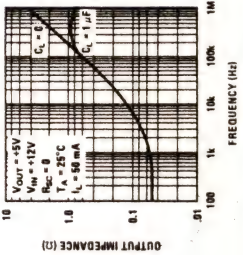
Line Transient Response



Load Transient Response



Output Impedance vs Frequency



typical applications

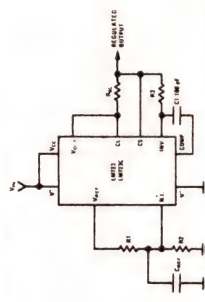


FIGURE 1. Basic Low Voltage Regulator (VOUT = 2 to 7 Volts)

Notes: R3 = 0, R1 = 20k, R2 = 10k, R4 = 10k, VOUT = 2.0V. R3 may be eliminated for minimum component count.

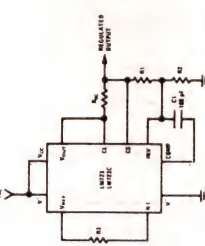


FIGURE 2. Basic High Voltage Regulator (VOUT = 7 to 37 Volts)

Notes: R1 = 10k, R2 = 10k, R3 = 10k, R4 = 10k, VOUT = 10V. R3 may be eliminated for minimum component count.

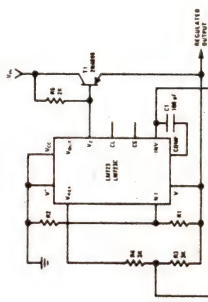


FIGURE 3. Negative Voltage Regulator (VOUT = -2 to -7 Volts)

Notes: R1 = 10k, R2 = 10k, R3 = 10k, R4 = 10k, VOUT = -10V. R3 may be eliminated for minimum component count.

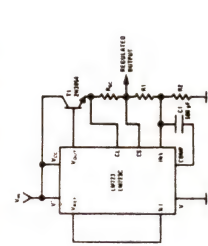


FIGURE 4. Positive Voltage Regulator (External NPN Pass Transistor)

Notes: R1 = 10k, R2 = 10k, R3 = 10k, R4 = 10k, VOUT = 10V. R3 may be eliminated for minimum component count.

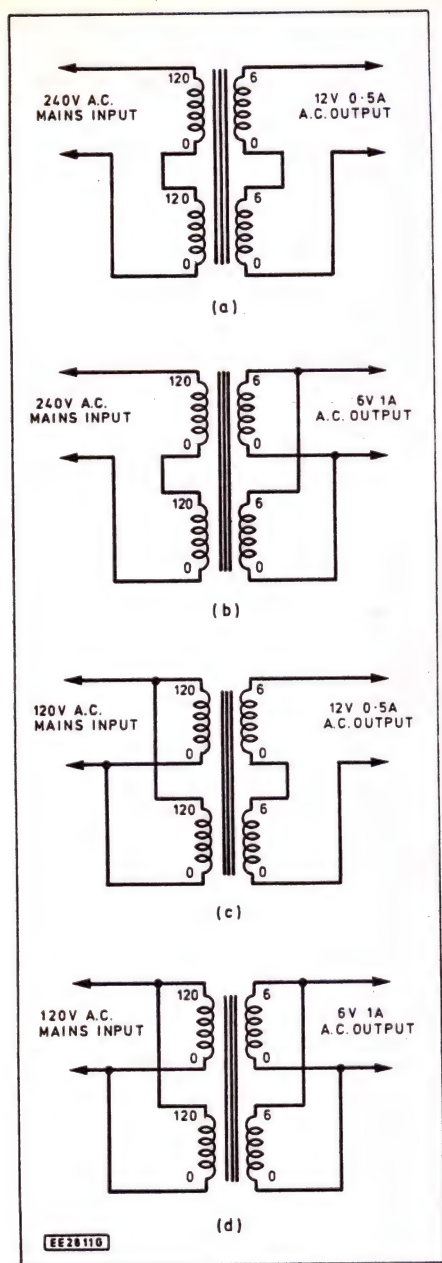
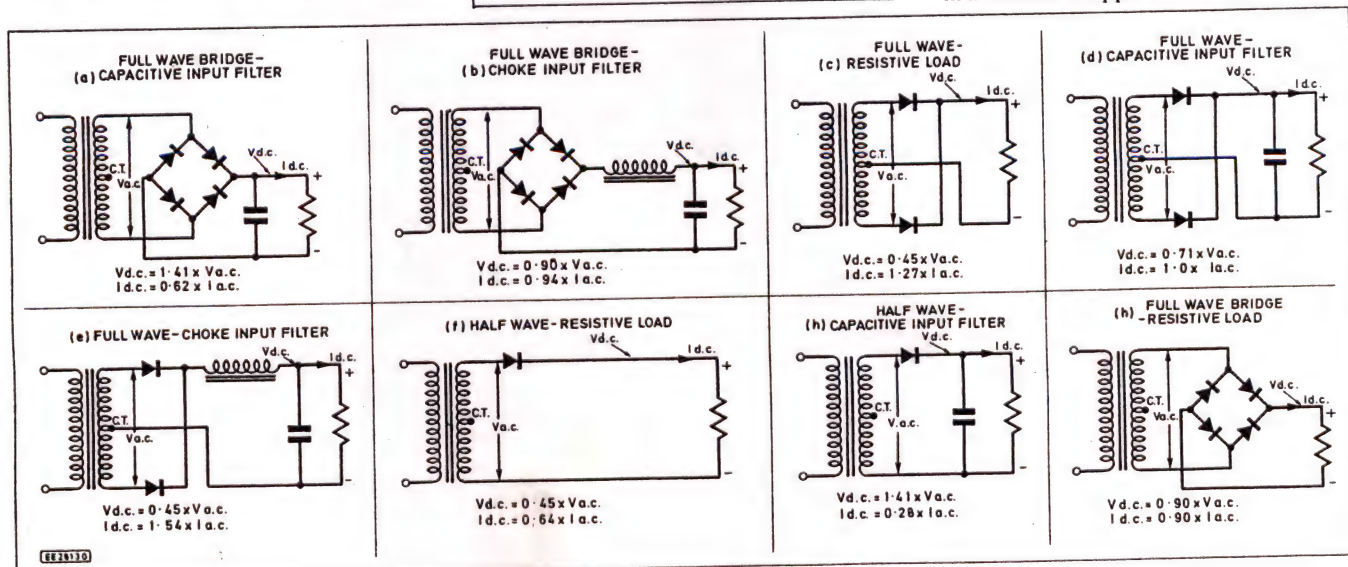


Fig. 1.5 Range of possibilities for connecting a 6VA transformer with two 6V 0.5A secondary windings

Fig. 1.7 Various rectifier arrangements



in parallel providing a unit which will provide 6V at 1A from an a.c. mains input of 120V.

In either case, it is important to ensure that the transformer windings are connected in the **correct phase**. This simply means that, in the case of a series connection the "finish" of one winding must be connected to the "start" of the other whilst, in the case of the parallel connection, the two "starts" must be connected together and the two "ends" connected together. Fig. 1.6a and 1.6b show the correct connections for series and parallel operation (respectively) whilst Fig. 1.6c and 1.6d show **incorrect connections**.

Non-resistive loads

Thus far, we have assumed that the transformer has been operating with a purely resistive load. Unfortunately, most rectifier arrangements impose a load on a transformer which is not equivalent to a pure resistance. Often the load will be capacitive although in some cases it may also be inductive. These **reactive** loads can result in the need to derate a transformer's a.c. current rating in order to prevent overloading. Recommended derating factors for various types of rectifier circuit have been included in Fig. 1.7.

Regulation

An important (though often misunderstood) characteristic of a transformer is its ability to maintain the rated output voltage at full-load. This **regulation** is usually quoted as a percentage and is determined from the following formula:

$$\text{Regulation} = \frac{V_{OL} - V_{FL}}{V_{OL}} \times 100\%$$

Where V_{OL} and V_{FL} are the off-load and full-load output voltages respectively.

Typical transformers have regulation which varies from 5% (usually for larger transformers) to around 20% (for smaller components). The implication of this is quite important and is one reason why a voltage regulator is often required after the rectifier stage. Consider the following example for two different transformers, each providing a single secondary winding rated at 12V 1A:

Component A (regulation 20%)

Since the component provides an off-load output of nominally 12V (i.e. $V_{OL} = 12V$), its full-load output (V_{FL}) will have dropped by 20%, thus:

$$V_{FL} = 12V - (12V \times 0.2) = 12V - 2.4V = 9.6V$$

Clearly, this would be quite unacceptable in a number of applications!

Component B (regulation 5%)

Since the component provides an off-load output of nominally 12V (i.e. $V_{OL} = 12V$), its full-load output (V_{FL}) will have dropped by 5%, thus:

$V_{FL} = 12V - (12V \times 0.05) = 12V - 0.6V = 11.4V$
Unfortunately, the old maxim "you get what you pay for" applies here since the cost of a transformer is very much related to the quality of the component and consequently is also related to the regulation which can be achieved. In practice, this means simply that, when purchasing a transformer, there is a trade-off between cost and performance!

Rectifiers

Rectifiers are another breed of component which, like transformers, are largely taken for granted. Here again, the choice of the "right" component can be crucial to the operation of a power supply.

Wire ended diodes are commonly available with maximum forward current (I_{FM}) ratings of up to around 6A and maximum repetitive reverse voltage (V_{RRM}) ratings of up to 1,250V. Stud-mounting diodes (designed for bolting to a heatsink) are available with forward current ratings ranging typically from 16A to 75A.

The following types of wire ended diode are commonly available:

Type	Encapsulation	Mounting	I_{FM} (typ)	Range of V_{RRM}
1N4000 series	Min. plastic	p.c.b.	1A	50V to 1000V
1N5400 series	Plastic	p.c.b.	3A	100V to 1000V
MR750 series	Plastic	p.c.b.	6A	200V to 800V
P600 series	Plastic	p.c.b.	6A	50V to 600V
BY126	Plastic	p.c.b.	1.5A	650V
BY127	Plastic	p.c.b.	1.5A	1250V
BYX10	Plastic	p.c.b.	0.35A	1600V

Most d.c. power supply circuits will make use of full-wave (bridge or bi-phase) rectification rather than half-wave. Hence the choice will involve either selecting two (or four) individual components or using an encapsulated bridge rectifier (comprising four individual bridge connected diodes). Fig. 1.7 shows a number of possible arrangements. Of these, the full-wave bridge with capacitive input is the most common, followed by the full-wave bi-phase circuit with capacitive input.

Rectifiers should be adequately rated in terms of both the maximum inverse voltage which they must withstand but also in terms of the maximum forward current which they must carry. In addition, components which are to be used in conjunction with capacitive input filters must generally be derated to around 80% of the quoted maximum forward current. As an example, a bridge rectifier rated at 1.6A used with a capacitive input filter should be derated to 1A maximum.

The following types of bridge rectifier are commonly available:

Type	Encapsulation	Mounting	I_{FM} (typ)	Range of V_{RRM}
DF series	4-pin d.i.l.	p.c.b.	0.9A	200V to 800V
Vm series	4-pin d.i.l.	p.c.b.	0.9A	200V to 800V
WO series	Cylindrical	p.c.b.	1A	50V to 800V
BY164	In-line	p.c.b.	1.5A	60V
SKB2 series	In-line	p.c.b.	1.6A	200V to 800V
KBPC series	Square	p.c.b.	2A/6A	200V to 800V
KBU4 series	In-line	p.c.b.	4A	200V to 800V
SKB25 series	Epoxy-potted	Heatsink	6A to 35A	200V to 1200V

Components which are expected to carry currents in excess of 2A, or so, will generally require fitting with a heatsink in order to reduce dissipation to an acceptably low value. A heatsink of $5^{\circ}C/W$ will generally suffice for current up to about 5A forward current whilst a component rated at $2.1^{\circ}C/W$ (or less) will be required for operation at 10A, or so. As with most semiconductor devices, rectifiers should be linearly derated at high temperatures (typically beyond $50^{\circ}C$) to zero at around $150^{\circ}C$.

The maximum inverse voltage (PIV or V_{RRM}) should be at least twice the peak value of the input voltage (purely resistive loads) or 2.8 times the input voltage (for a capacitive input filter). In practice, and to allow a margin for safety, it is wise to employ a component which is rated at **at least four times** the quoted r.m.s. secondary voltage of the transformer. Hence, a rectifier for use in conjunction with a transformer which has a 12V secondary should be rated at 48V, or more. In practice, a 50V or 200V component would be suitable.

Worst case conditions

As shown in Fig. 1.7, the output voltage developed across the capacitor of a capacitor input filter circuit will be approx-

imately 1.4 times the transformer secondary voltage. On-load, this voltage will fall due in part to the regulation offered by the transformer and in part due to the forward voltage drop of the diodes within the bridge rectifier. In order to ensure that operation is within specification, it is important to be aware of the "worst case" condition" which occurs at full-load.

It is worth dwelling on this point a little! Let us suppose that we are making use of a transformer with a secondary voltage of 12V at 1A which offers a regulation of 10%. At full-load, the a.c. voltage provided by the secondary will fall by 10% to 10.8V and the corresponding peak output voltage developed across the reservoir capacitor will be 1.4 times this value **minus** the forward voltage drop associated with **two** silicon diodes within the bridge rectifier (note that there are two diodes in the current path at any one time). Hence the worst case output voltage will be given by:

$$V_O \text{ (worst case)} = 1.4 \times 10.8V - 2 \times 0.7V \\ = 15.12V - 1.4V = 13.7V$$

Question 2: Determine the worst case voltage developed across the reservoir capacitor in a full-wave bridge rectifier circuit which operates with the following parameters:

Transformer off-load secondary voltage (V_{OL}) = 9V

Diode forward voltage drop (per diode)

(V_F) = 0.7V

Transformer regulation = 15%

Typical values of no-load output voltage for the circuit of Fig. 1.7a are as follows:

R.M.S. secondary voltage	No-load d.c. output voltage
4.5V	6.3V
6V	8.5V
9V	12.7V
12V	16.9V
15V	21.2V
18V	25.4V
20V	28.2V
24V	33.9V

Reservoir capacitors

The value of reservoir capacitor used in the circuits shown in Fig. 1.7 will be governed by the load current and the amount of ripple that can be tolerated. In addition, maximum reservoir capacitance values are sometimes specified by rectifier manufacturers. As a "rule of thumb", the capacitance value (expressed in μ) should be between 2,000 and 5,000 times the maximum load current (expressed in A). If a regulator is fitted (and provided that sufficient headroom voltage is available) the value of capacitance may be closer to the lower limit. Hence the following values are recommended:

Nominal load current	Reservoir capacitance
125mA	220 μ to 470 μ
250mA	470 μ to 1000 μ
500mA	1000 μ to 2200 μ
1A	2200 μ to 4700 μ
2A	4700 μ to 10000 μ
4A	10000 μ or greater

It is important to ensure that the component selected is adequately rated in terms of maximum working voltage. To provide a margin of safety, the reservoir capacitor should be rated at about twice the r.m.s. secondary voltage of the transformer. Hence, a component for use in a full-wave bridge rectifier circuit using a capacitive input filter Fig. 1.7a in which the transformer is rated at 12V a.c. output should be rated at a minimum of 24V d.c. working (even though, in normal operation, the off-load d.c. output voltage will only reach about 16V). In practice, reservoir capacitors are available in ranges of different working voltages (usually 16V, 25V, 35V, 50V, 63V and 100V).

Simple regulators

Regulation of the output voltage of a power supply is important in nearly every application and, in some simple applications, can be achieved by nothing more than a Zener diode, a transistor and a few additional components.

Zener diodes are available in various families (according to their general characteristics, encapsulation and power ratings) with reverse breakdown (Zener) voltages in the E12 and E24 series (ranging from 2.7V to around 68V).

The following data applies to the most common families of Zener diode:

Zener family	Power rating	Encapsulation	Voltage range
BZY88 series	500mW	Min. glass	2.7V to 15V
BZX85 series	1.3W	Min. glass	5.1V to 62V
BZX61 series	1.3W	Min. glass	7.5V to 72V
BZX55 series	500mW	Min. glass	2.4V to 91V
BZY93 series	20W	Stud mounting	9.1V to 75V
BZY97 series	1.5W	Plastic	9.1V to 37V
1N5333 series	5W	Plastic	3.3V to 24V

Where accuracy of the Zener voltage is an important consideration, it is important to note that the temperature coefficient of the Zener voltage of a Zener diode tends to vary with the Zener voltage rating. The temperature coefficient for a 2.7V component will usually be of the order of -2mV/deg.C whilst a 6.8V component will exhibit a temperature coefficient of around $+2\text{mV/deg.C}$. The optimum voltage (at which the temperature coefficient approaches zero) is around 4.7V. Hence this voltage may be preferred for certain applications (particularly where the Zener voltage is used as a "reference" voltage).

Shunt regulators

The simple shunt Zener voltage regulator shown in Fig. 1.8 is only suitable for applications in which the load current is less than about 50mA. A regulation of about 10% can be achieved with this type of circuit which will exhibit an impedance of typically 15 ohm, or less.

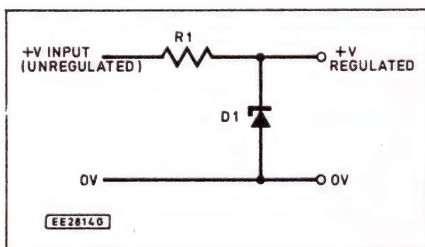


Fig. 1.8 Simple Zener diode shunt regulator

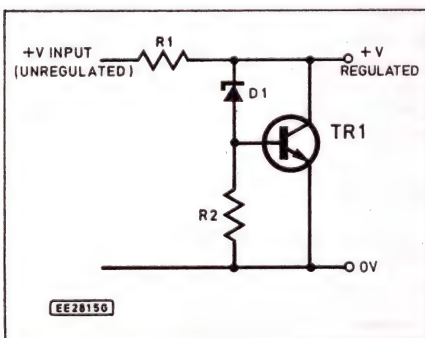


Fig. 1.9 "Amplified Zener" shunt regulator

The performance of a Zener regulator can be considerably improved by adding a shunt connected transistor, as shown in Fig. 1.9. This "amplified Zener" arrangement is suitable for applications in which the load current is very much greater than the maximum rated current of the Zener (found by dividing its maximum permissible power dissipation by its nominal Zener voltage). The compound arrangement of Zener and transistor behaves like a superior Zener diode having a much higher power rating.

The circuit shown in Fig. 1.9 has an output impedance of less than 1 ohm but note that, by virtue of the base-emitter voltage drop of the transistor, the output voltage will be approximately 0.8V greater than the nominal Zener voltage.

Unfortunately, high current shunt regulators have several obvious disadvantages not the least of which is associated with the power dissipation in the series dropping resistor. This must be adequately rated (a wirewound resistor will usually be required) and mounted so that convection cooling is possible. Another problem is that maximum dissipation in the shunt transistor occurs under no-load conditions. It, too, will probably require heatsinking!

Despite this, shunt regulators do offer one advantage over their series connected counterparts; they are inherently safe since a collector-emitter short circuit failure within the transistor will make the output fall to zero. A similar fault condition in a series regulated power supply will result in the full unregulated d.c. voltage being applied to the load. In some cases this can prove to be extremely embarrassing (not to mention expensive!) since it can result in wholesale destruction of any voltage sensitive devices present in the load which may have their maximum ratings exceeded whenever the series transistor fails!

Series regulators

The basic arrangement of a series regulator is shown in Fig. 1.10. The transistor is effectively connected as an emitter follower and thus the output voltage will be approximately 0.8V less than the nominal Zener voltage. Dissipation in the series element rises as the load current increases. Under worst-case conditions (i.e. under full-load and with the minimum expected value of the a.c. mains supply), the input voltage should be at least 2V greater than the desired output.

In order to minimise dissipation in the transistor (and thus minimise heatsink ratings) the d.c. input should not, however, be very much greater than this value. A recommended range for the input would be between 2V and 7V greater than the desired output voltage. Thus, for a nominal 12V output, the rectifier output should be within the range 14V (minimum) to 19V (maximum).

Integrated circuit voltage regulators

Integrated circuit voltage regulators are now so widely available in popular ranges of voltage and current output that discrete component regulator circuits are nowadays hardly ever necessary. In addition, integrated circuit regulators offer a number of significant advantages over simple circuits which employ discrete components

including such useful features as foldback current limiting and thermal shut-down.

The 78 (positive output) and 79 (negative output) regulators are available in a range of voltages (e.g. 5V, 9V, 12V, 15V, 18V and 24V). Current ratings for different variants range from 100mA (L series) to 5A (H series). The most commonly available range are designed to operate at load currents of up to 1A.

Basic positive and negative regulated power supplies are shown in Fig. 1.11. The two 100n capacitors (C1 and C2) are included to ensure unconditional high frequency stability and they should be mounted as close to the regulator terminals as possible. C3 is placed in parallel with the output simply to provide additional decoupling. In practice, any value between 22μ and 100μ should prove adequate.

When using 78 series regulators, it is important to note that the worst-case unregulated d.c. input voltage should normally be at least 3V greater than the nominal regulated output voltage. The penalty for not observing this precaution will be poor regulation and an unacceptable level of residual mains hum present at the output. Furthermore, the worst-case unregulated d.c. input voltage should not be allowed to exceed the nominal regulated output voltage by more than about 15V otherwise regulator dissipation will be excessive. Failure to avoid this precaution can result in premature thermal shut-down. Typical characteristics of 100mA, 1A and 2A plastic fixed voltage regulators are shown opposite:

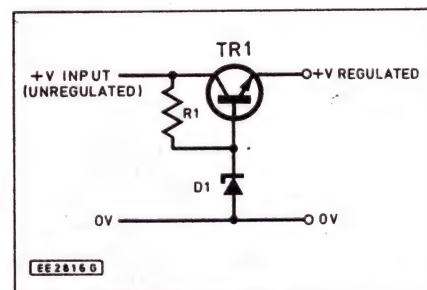


Fig. 1.10 Basic series regulator

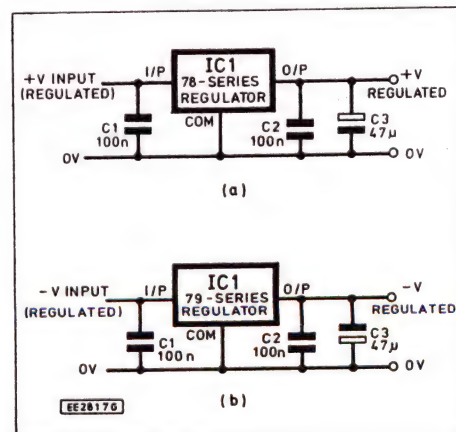


Fig. 1.11 Integrated circuit regulator arrangements, (a) positive output, (b) negative output

Dual output power supplies

When dual regulated outputs are required, a bridge rectifier can be used in

100mA series

Type	Positive output Negative output	78L05 79L05	78L12 79L12	78L15 79L15	78L24 79L24
Input voltage range	(V)	7-30	14.5-35	17.5-35	27-35
Load regulation	(%)	0.2	0.2	0.3	0.4
Line regulation	(%)	1	1	1.5	1.5
Ripple rejection	(dB)	60	55	52	49
Output resistance	(mΩ)	200	400	500	850
Output noise voltage [10Hz TO 100KHz]	(μV)	40	70	90	200
Short-circuit current	(mA)	75	35	25	20

1A series

Type	Positive output Negative output	7805 7905	7812 7912	7815 7915	7824 7924
Input voltage range	(V)	7-25	14.5-30	17.5-30	27-38
Load regulation	(%)	0.2	0.4	0.5	0.6
Line regulation	(%)	0.2	0.2	0.3	0.3
Ripple rejection	(dB)	71	61	60	56
Output resistance	(mΩ)	30	75	95	150
Output noise voltage [10Hz to 100kHz]	(μV)	40	80	90	170
Short-circuit current	(mA)	750	350	230	150

2A series

Type	Positive output Negative output	78S05 79S05	78S12 79S12	78S15 79S15	78S24 79S24
Input voltage range	(V)	8-35	15-35	18-35	27-40
Load regulation	(mV)	100	160	180	250
Line regulation	(mV)	100	240	300	480
Ripple rejection	(dB)	60	53	52	48
Output resistance	(m)	17	18	19	28
Output noise voltage [10Hz to 100kHz]	(μV)	40	75	90	170
Short-circuit current	(mA)	500	500	500	500

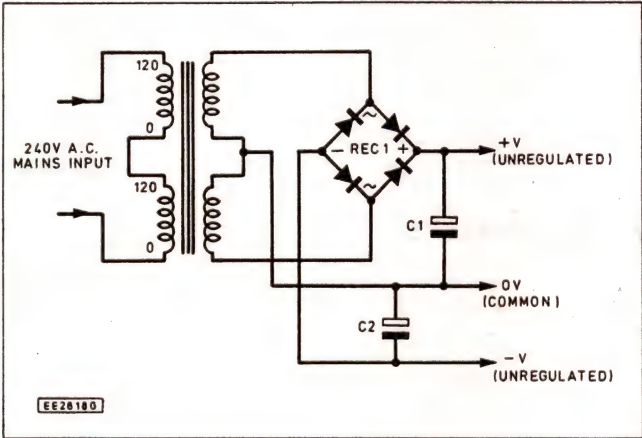
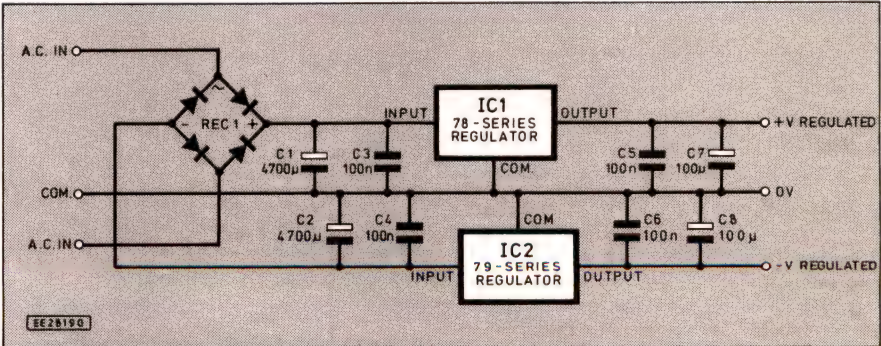


Fig. 1.12 Dual output rectifier circuit

Fig. 1.13 Circuit diagram of the dual output power supply module

conjunction with a transformer having two identical secondaries, as shown in Fig. 1.12. With this arrangement it is important to note that the maximum reverse repetitive voltage rating (V_{RRM}) for the diodes in this circuit should at least be equal to 2.8 times the r.m.s. voltage produced by each individual secondary winding.

The unregulated positive and negative outputs produced by the circuit of Fig. 1.12 can be regulated by means of two fixed voltage regulators of opposite polarity. Fig. 1.13 shows the complete circuit of a dual output power supply module based on standard 78 and 79 series regulators. The necessary component changes for different output voltages are given in the table below the circuit.



Output	IC1	IC2	Transformer secondaries (each rated at 2.2A minimum)	Transformer power rating (minimum)
± 5V	7805	7905	2 × 4.5V or 1 × 9V	20VA
± 12V	7812	7912	2 × 6V or 1 × 12V	27VA
± 15V	7815	7915	2 × 9V or 1 × 18V	40VA

COMPONENTS

Dual-Output Power Supply Module

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Capacitors

C1, C2 4700μ axial elect. 25V (2 off)
C3 to C6 100n miniature dipped case polyester (4 off)
C7, C8 100μ axial elect. 25V (2 off)

Semiconductors

REC1 200V min. 2.6A in-line type (e.g. KBU4D)
IC1 7805, 7812 or 7815 (see table)
IC2 7905, 7912 or 7915 (see table)

Miscellaneous

T1 20VA mains transformer with two secondary windings (see table)
Heatsink, 4°C/W (see text); p.c.b., available from the EE PCB Service, order code 712; Terminals, 0.042" terminal pins (6 off)

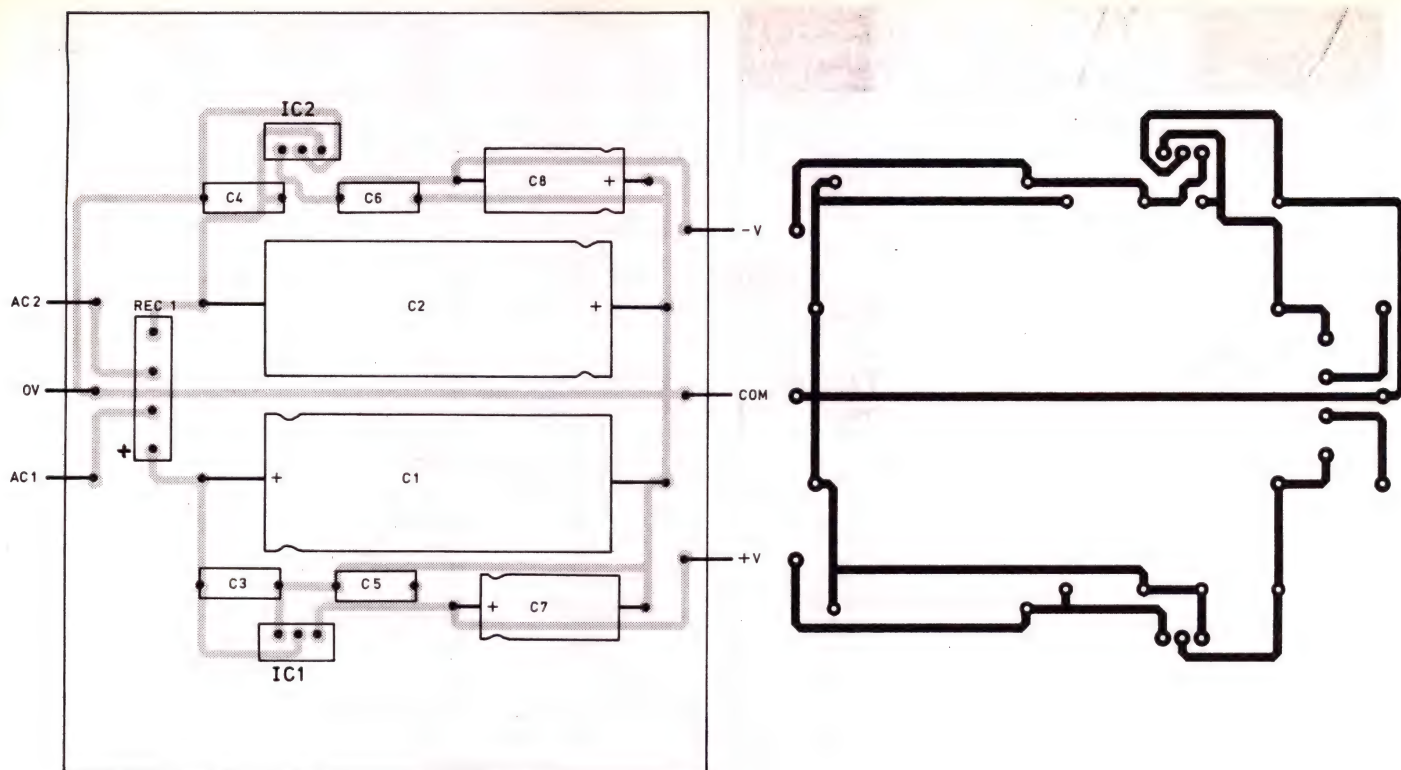
Approx cost
guidance only

£8

The copper foil and p.c.b. component layouts for the dual output power supply module are shown in Fig. 1.14

Variable power supplies

Where a variable regulated output voltage is required it is expedient to make use of a variable i.c. voltage regulator such as the LM317 or LM338. These versatile devices provide an adjustable output voltage range of 1.2V to over 30V (depending upon the upper limit of the unregulated d.c. input voltage) and incorporate the usual internal current limiting, thermal and safe operating area protection.



EE28200

The characteristics of the LM317/ LM338 family are listed below:

Fig. 1.14 P.C.B. copper foil and component layout for the dual output power supply module

Type	LM317L	LM317M	LM317T	LM317K	LM338K
Maximum load current	100mA	500mA	1.5A	1.5A	5A
Output voltage range (V)	1.2-37	1.2-37	1.2-37	1.2-37	1.2-32
Input voltage range (V)	4-40	4-40	4-40	4-40	4-35
Load regulation (%)	0.1	0.1	0.3	0.1	0.1
Line regulation (%/V)	0.01	0.01	0.02	0.01	0.005
Ripple rejection (dB)	65	65	65	65	60
Output impedance (m)	10	10	10	10	3
Adjustment pin current (μA)	50	50	50	50	45
Thermal resistance [junction case] (deg.C/W)	160	12	4	2.3	1
Maximum junction temperature (deg.C)	125	125	125	125	125
Maximum dissipation (W)	0.625	7.5	15	20	50
Package	TO92	TO202	TO220	TO3	TO3

of up to 1.5A. Fig. 1.17 shows the circuit of a 5A power supply which has an adjustment voltage range of 9.5V to 13.8V (the LM338K should be mounted on a heatsink rated at 1 deg.C/W, or better). This power supply makes an ideal bench replacement for a 12V lead-acid battery!

Where it is necessary to provide a means of adjusting the output current as well as the output voltage provided by a monolithic regulator, an LM723 regulator may be preferred. This device was described earlier and has established a long track record as a reliable and predictable "industry standard" device.

The circuit diagram of a complete power supply module based on an LM723 is shown in Fig. 1.17. Almost any suitably rated high power *npn* silicon transistor can be used as the series pass device, TR1 (for which an adequate heatsink, e.g. 2 deg.C/W, will be required). Adjustment of the output voltage and current limit is

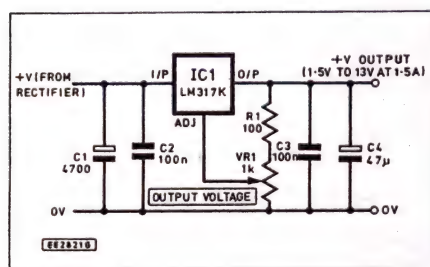


Fig. 1.15 Variable regulated power supply based on an LM317K

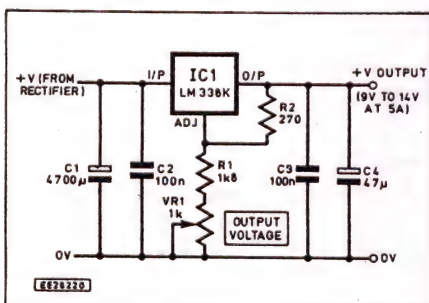


Fig. 1.16 Variable regulated power supply based on an LM338K

Representative circuits using variable voltage regulators are shown in Fig. 1.15 and 1.16. The circuit of Fig. 1.15 uses an LM317K (which should be mounted on a heatsink rated at 2 deg.C/W, or better) and provides an output voltage which is fully variable from 1.5V to 13V at load currents

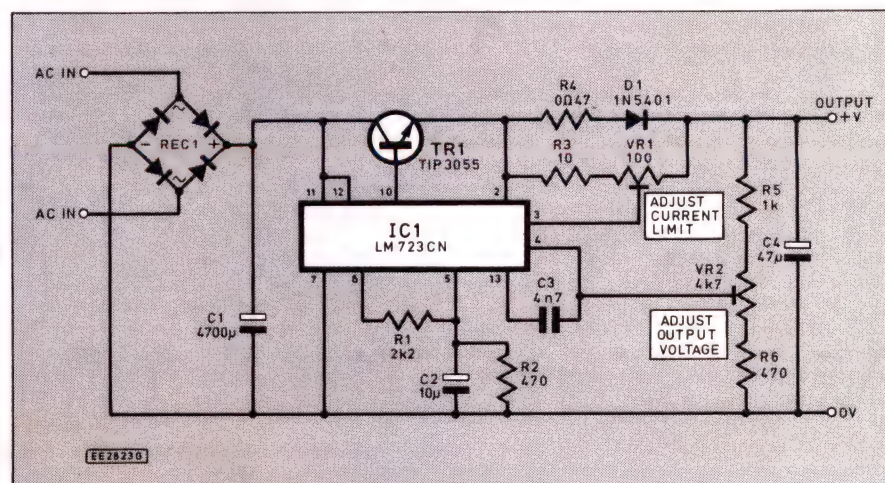


Fig. 1.17 Circuit diagram of the LM723 variable power supply module

COMPONENTS

LM723 Power Supply Module

Resistors

R1	2k2 0.25W 5% carbon
R2, R6	470 0.25W 5% carbon
R3	10 0.25W 5% carbon
R4	0Ω47 2.5W 5% vitreous coated
R5	1k 0.25W 5% carbon

Potentiometers

VR1	100 0.5W horiz. cermet preset
VR2	4k7 0.5W horiz. cermet preset

Capacitors

C1	4700μ axial elect. 25V
C2	10μ radial elect. 16V
C3	4n7 miniature plate ceramic
C4	47μ radial elect. 50V

NB: Capacitor maximum working voltages are shown for a nominal 12V a.c. input. Values of working voltage should be uprated appropriately for higher voltage operation (see text).

Semiconductors

REC1	200V 4A in-line type (e.g. KBU4D)
IC1	LM723CN
TR1	TIP3055
D1	1N5401

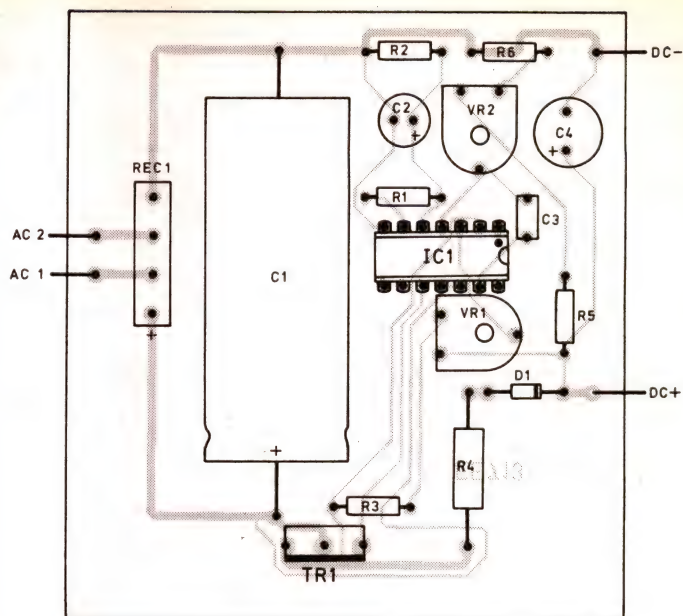
Miscellaneous

T1 50VA (min.) mains transformer with suitable rated secondary windings (see text)
Heatsink, see text; terminals 0.042" terminal pins (4 off); p.c.b., available from the *EE PCB Service*, order code EE713.

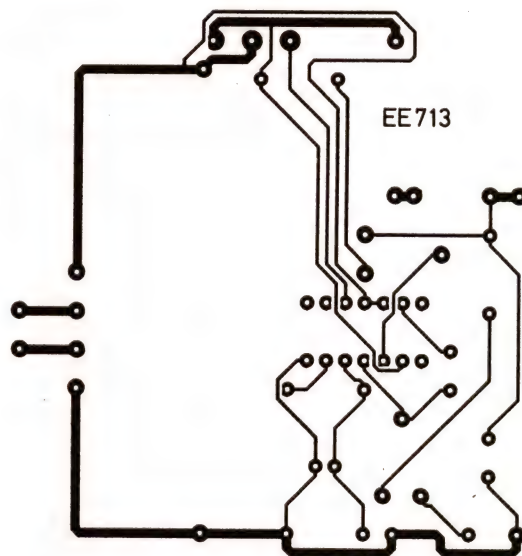
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EE28240



EE713

Fig. 1.18 P.C.B. copper foil and component layout for the LM723 power supply module

achieved by means of VR2 and VR1 and the circuit is capable of supplying outputs of up to 5A at voltages of up to 35V. The range of output voltage adjustment may be reduced (or increased) by appropriate changes to the potential divider formed by R5, R6 and VR2. The LM723 data sheet shown in Fig. 1.4 gives the necessary information.

The copper foil and p.c.b. component layouts for the dual output power supply module are shown in Fig. 1.18. Note that the power transistor, TR1, may be mounted on or off the p.c.b. according to the amount of heatsinking required. If a TO3 device is used (e.g. 2N3055) this can be wired to the p.c.b. by means of short lengths of insulated stranded wire (which **MUST** be capable of carrying the maximum rated output current).

In some cases, an L200 regulator may be preferred to the LM723. The L200 provides an adjustable output voltage range of 2.8V to 36V together with an adjustable output current range with a 2A upper limit. The device is housed in a 5-pin plastic package. Load regulation is typically 1.5% and the device incorporates safe operating area protection as well as input overvoltage protection (up to 60V, 10ms) and short-circuit protection.

The circuit of Fig. 1.19 shows how the L200 can be used in a simple power supply which produces an output which can be varied from approximately 2.7V to 35V at

2A maximum. It should be noted that, regulator dissipation will be large when operating near the maximum rated current (2A) with low output voltages. An adequate heatsink (2 deg.C/W, or better) is therefore essential in order to prevent premature thermal limiting of the output current.

The copper foil and p.c.b. component

layouts for the L200 power supply module are shown in Fig. 1.20

Crowbar protection

Short circuit failure within the series pass element of a regulator can have

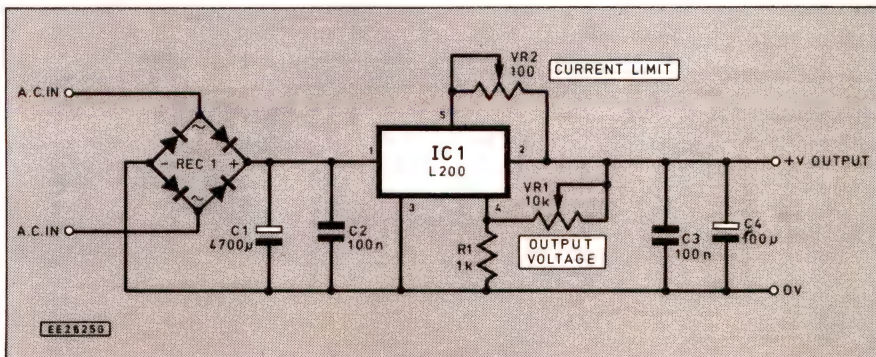


Fig. 1.19 Circuit diagram of the L200 variable power supply module

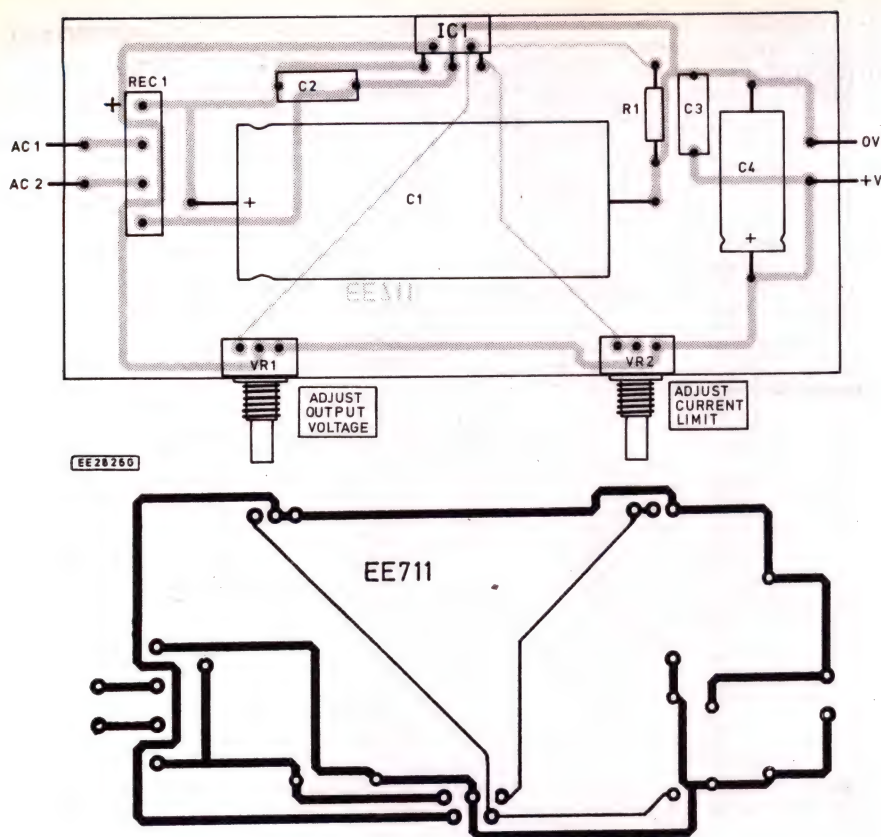


Fig. 1.20 P.C.B. copper foil and component layout for the L200 power supply module

catastrophic consequences since the full unregulated d.c. voltage will be transferred directly to the output. In the case of TTL circuits, for example, a regulator may be fed with an unregulated d.c. input in excess of 10V. If the output should ever rise much above 7V, however, most TTL devices connected to the nominal 5V rail will self-destruct virtually instantaneously!

The dire consequences of such a failure can be avoided by the incorporation of a "crow-bar" over-voltage protection circuit of the type shown in Fig. 1.21. This circuit places a virtual short-circuit across the supply whenever the rail voltage exceeds approximately 6.1V. The circuit can be readily adapted for operation with other voltages using the formula:

$$\text{Crow-bar voltage, } V = V_Z + V_{GT}$$

where V_Z is the Zener voltage and V_{GT} is the thyristor gate trigger voltage (for the BT152, $V_{GT} = 1V$ approx.).

It is important to note that once triggered, the thyristor remains in the conducting state until the supply is disconnected or a mains fuse ruptures. The action of the circuit may appear to be somewhat crude but it does make a useful "last-ditch" protection!

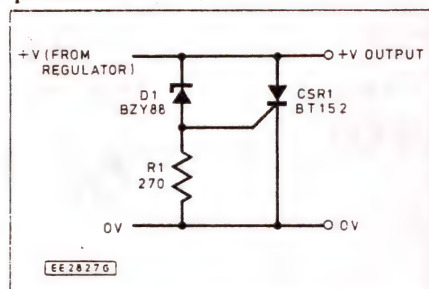


Fig. 1.21 Basic crow-bar over-voltage protection circuit

Current Limit

Most general purpose commercial power supplies are fitted with a current limit (usually variable) which allows the user to adjust the threshold of output current at which the output voltage rapidly falls to zero.

The current limit control is normally adjusted to the maximum current value associated with the circuit which is connected to the power supply. In the event of a fault arising (such as a short-circuit capacitor across the supply rail or short-circuit out-

COMPONENTS

L200 Power Supply Module

See
**SHOP
TALK**
Page

Resistors

R1 1k 0.25W
5% carbon

Potentiometers

VR1 10k 1W p.c.b. mounting lin.
VR2 100 1W p.c.b. mounting lin.

Capacitors

C1 4700µ axial elect. 25V
C2, C3 100n miniature dipped case
polyester (2 off)
C4 100µ axial elect. 25V

NB: Capacitor maximum working voltages are shown for a nominal 12V a.c. input. Values of working voltage should be updated appropriately for higher voltage operation (see text).

Semiconductors

REC1 200V 2.5A (min.) in-line
bridge rectifier
IC1 L200 regulator

Miscellaneous

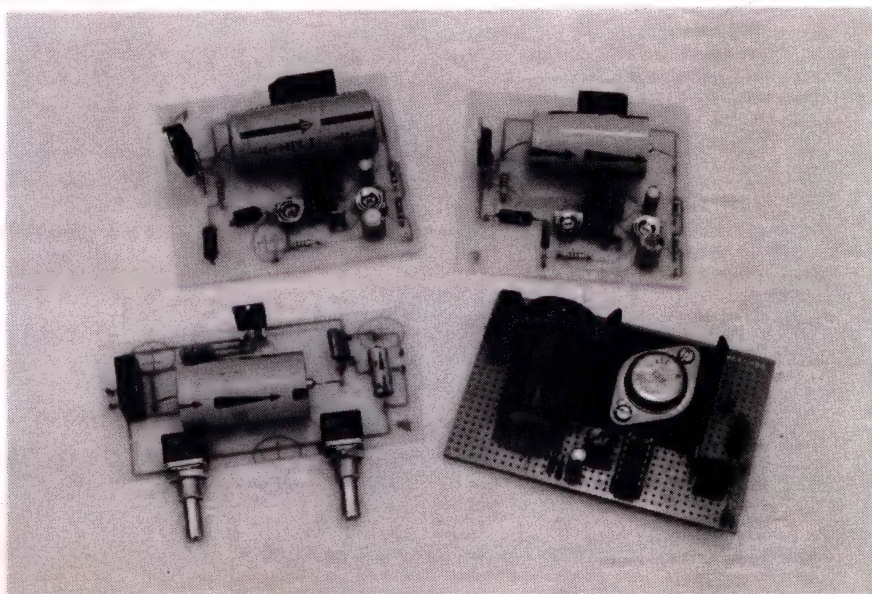
T1 30VA (min.) mains transformer
with suitable rated secondary
windings (see text)
Heatsink, see text; terminals 0.042"
terminal pins (4 off); p.c.b., available
from the *EE PCB Service*, order code EE
711.

Approx cost
guidance only

£13

put transistor), the current trip will operate and protect both the equipment and power supply from the results of an excessive supply current.

Operation of a current trip is usually virtually instantaneous (i.e. within a few microseconds) rather than the milliseconds associated with conventional fuses.



Three prototypes for the 723 power supply modules plus the L200 module.

Failure to set a current trip at a sufficiently high current can sometimes cause rather strange effects including a form of low-frequency instability (in which the equipment is rapidly switched on and off by the current trip repeatedly operating and releasing).

Most bench power supplies are fitted with voltage and current meters which may be either of digital or analogue type. Some instruments use a single analogue meter movement (or digital display) which can be switched to read either voltage or current. In such a case, it is important to ensure that the meter is switched to display voltage (*not* current) before using the power supply and to check that the required voltage is set *before* connecting the equipment on test. Failure to observe such a simple precaution can sometimes result in the destruction of components (just imagine the effect of connecting a 30V supply to a piece of equipment designed for operation on 3V!).

Design Problem

This month's exercise, in common with all of our design problems, is designed for readers who would welcome the opportunity of tackling a little "homework" and, whilst the exercise can be accomplished purely "on paper", some of you may wish to go further by building and testing your solutions. This month's problem arises from the need for a means of calibrating an oscilloscope:

An oscilloscope is to be fitted with an accurate d.c. voltage calibrator. This circuit is to provide fixed d.c. levels of 100mV, 1V and 10V at a front-panel test point. The voltage levels should be accurate to within $\pm 2\%$ and the voltage level should be maintained within this range when the test point is "loaded" by a standard oscilloscope input (equivalent to 1Mohm). Design a suitable circuit arrangement based on a standard voltage regulator operating from an internal +18V rail. Specify all component values required.

Answers to questions in Part One

Question 1	(a) 40V (b) +70°C (c) pin-12 (d) 9.5V (e) 2.0V (f) 0.03% of V_{OUT} (g) 65mA (h) 50mA (i) 600mW
Question 2	0.24V
Question 3	60VA
Question 4	6.25V

Cumulative index to modules

Title	Part	Function/specification
Dual output power supply	1	Dual $\pm 5V$, $\pm 12V$ or $\pm 15V$ regulated power supply rated at 1A max. output
723 variable power supply	1	Single variable output of +2V to +37V at up to 5A max. Output voltage and current limit are set by means of preset controls.
L200 variable power supply	1	Single variable output of +2.7V to +35V at up to 2A max. Output voltage and current limit are set by means of variable controls.

Next month: In next month's instalment we deal with transistor and operational amplifier circuits. Our design problem involves a microphone pre-amplifier whilst our practical project involves the construction of an intercom system.

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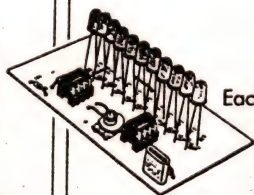
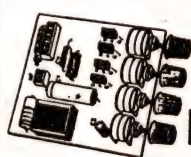
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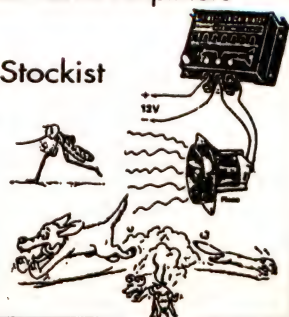
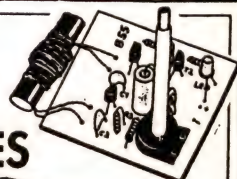
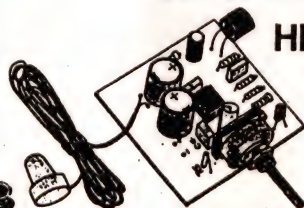
- * Antenna Amplifiers
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- * Micro-Wave Indicators
- * Lighting Consoles
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FOR YOUR ENTERTAINMENT

by Barry Fox



Getting Taped

The tape companies continually complain that it is virtually impossible to sell high grade domestic video tape in Britain. People just go for the cheapest price tag. And there is nothing to stop manufacturers putting a "high grade" label onto the lowest grade tape, because there are no agreed technical specifications which define the grades.

The packaging and publicity material is confusing because it usually only talks about performance (e.g. the ratio of wanted signal to unwanted random noise on luminance picture detail and chrominance colour wash) being several dB better than the company's own reference tape. A fat lot of help that is!

Catch a tape maker in an honest mood, and he may just admit that for time-shifting there is really no point in spending extra money on high grade tape if good standard grade is available. This is because there is very little visible benefit when the video signal-to-noise ratio is raised above 40dB. It's a threshold, below which the pictures on screen start to look fuzzy, but above which the couple of extra dB gained from using better tape can only be seen by experts with a trained eye.

The benefit of a signal-to-noise ratio above 40dB becomes apparent when the tape is dubbed through several generations, for instance for editing camcorder movies. That's when it really does pay to pay for high grade tape, which can push S/N ratios out to 44 or even 46 dB.

It's also one of the real advantages of S-VHS, where the luminance performance is improved by the higher carrier frequency for S-VHS, and the colour performance is improved because S-VHS tape is by specification of higher quality and coercivity than standard VHS tape.

It's odd that the tape industry has never got its act together on the need to educate the public over the real benefits of high grade tape. Education is the key, and they just haven't educated us. Could this be because a lot of people selling tape don't understand the first thing about the technology?

Screen Speaker

A couple of neat ideas popped up in patent applications recently. West German company E W D Electronic-Werke is filling patents around the world on a way of improving the sound of a TV set without increasing its size.

E W D proposes that the screen and loudspeaker be combined. This is done by making the loudspeaker from a transparent film of piezopolymer, which overlays the screen.

All piezoelectric materials flex and move when an electric current passes

through them. When the current is a fluctuating audio signal, the material vibrates at audio frequencies.

The result should be good sound, because the loudspeaker diaphragm is as large as the TV screen. But there is no addition to the size of the TV set cabinet. An added benefit is that the sound appears to be coming direct from the mouths of actors depicted on the screen.

Mindlink

In 1984, at the Chicago Consumer Electronics Show, Atari demonstrated "Mindlink" a headband that was claimed to control a computer video game "by power of your mind alone". The demonstrator said it sensed electrical signals from the brain. Concentrate hard, they told everyone who tried it.

I reckoned that the headband just sensed any slight change in pressure e.g. from a furled brow. I quickly took mine off during a demonstration and (before being jumped on by the Atari people) found it had three pressure senses that worked just as well if you pressed them with your finger. Predictably, Mindlink soon disappeared without trace.

Now, computer firm Wang of Lowell, Massachusetts is patenting a headband that controls the cursor on the screen of a desktop computer, without the need to move a mouse or keyboard cursor keys. This leaves the user's hands free to do other work or control other functions of the keyboard. It also makes it easier for handicapped workers to operate a computer. The same system could be used to play video games. But there is no non-sense talk of sensing brainwaves.

Wang's patent application shows a

Cycling Computer

Here's a mental challenge, and a neat way of shutting up people who say "computers will soon be able to do even the most complicated things."

Devise a hardware-software system that rides a bicycle through traffic—something that humans do every day, without thinking, or while thinking about something completely different.

The pedalling drive is the easy part, once you have found batteries that can deliver the power needed and recharge on a plate of cornflakes and slice of toast!

Now build a level sensor system with feedback loop which continually adjusts the balance of the load on the two wheel support to stop the whole thing falling over. The adjustments will have to be very fast, and cope with all speeds from stationary to downhill cruising, as well as uphill wobbling, uneven roads and camber on corners.

band which clips over the top of the user's head, like a pair of personal stereo headphones. The band supports a spherical container, like a tennis ball. The sphere is half filled with liquid in the lower half of the sphere and gas, such as air, in the upper half.

When the user's head is upright, the boundary is horizontal. When the user's head tilts, the boundary changes its angle with respect to the sphere.

The change in boundary angle is sensed by a cluster of light emitting diodes mounted inside the top of the sphere and beaming pencils of light down through the liquid boundary onto photodetector diodes mounted inside the lower part of the sphere, and submerged in the liquid.

When a light pencil is perpendicular to the liquid boundary, it passes through to the diodes unhindered. When the pencil strikes the boundary at an angle, at least some of the light is refracted, so the photo diode senses a drop in light.

There are four pairs of transmitter and receptor diodes, each 90 degrees apart, and each angled at 45 degrees to the fluid boundary. Comparison of the electrical outputs from the four sensors gives an accurate indication of both the direction of rotation of the sphere and the magnitude of rotation. This in turn gives an electrical representation of the position of the computer user's head.

It is a simple step to convert the output signals from the orientation sensors into digital code, which is formatted to simulate the cursor control signals put out by a keyboard or mouse. In this way the user is able to aim a cursor at any part of a TV or computer screen, simply by head movement.

Don't forget the need for three dimensional vision to detect distances, with side vision to avoid any pedestrians that step off the pavement and peripheral vision to get advance warning of any vehicles coming up close from behind. And you will need sound sensing too, in stereo to pinpoint the direction of cars and horns.

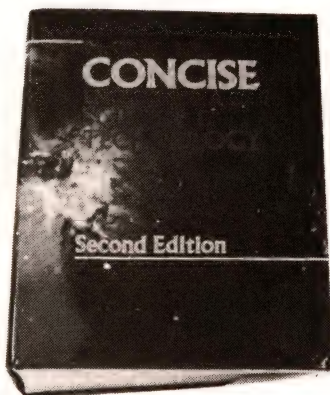
Both the sound and vision systems will of course have to work in the main feedback control loop, judging the speed and relative speed of several objects at the same time, to avoid collisions. Predictive software, based on a memory bank of past experience will be needed to replicate a cyclist's sixth sense feeling that the pedestrian or car ahead may do something wholly unpredictable.

Finally, all this work must be done as background processing, to leave the computer's "mind" clear to think nice thoughts and enjoy the scenery.

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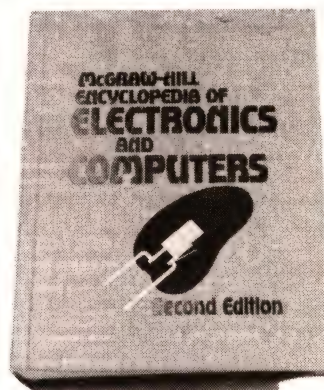
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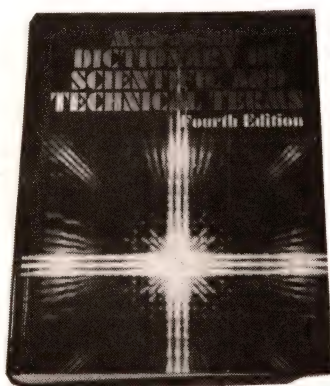
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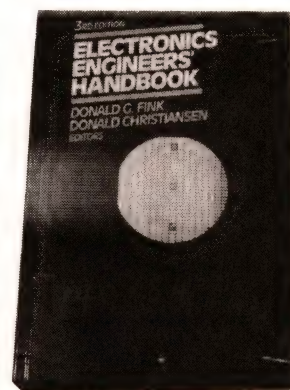
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COLOUR CHANGING CHRISTMAS LIGHTS

MARK DANIELS



A low cost project to add some colour to the festive season

THE ILLUMINATION of Christmas trees has not seen any significant changes for many years. Originally they were lit with candles and more recently with coloured lamps which are sometimes made to flash. But imagine if the lamps themselves were to actually change colour as you watched them. From red to green to yellow and back again.

Obviously this cannot be achieved using ordinary Christmas lights, and in this design the effect is obtained by using bi-colour i.e.d.'s, with an electronic control unit and power supply. The resulting display is very effective and the timing may be adjusted to give numerous different patterns.

BI-COLOUR L.E.D.

As already mentioned this project uses bi-colour i.e.d.s to produce the three colours, red, green and yellow (depending on the i.e.d.s used the yellow may appear as orange). The Bi-colour i.e.d.'s used are packaged in a colourless translucent plastic encapsulation.

The two i.e.d. chips, one red, one green are connected across the two package leadout pins in inverse parallel. Thus when current is passed through the device one or other of the i.e.d.'s will illuminate. This will give either red or green depending on the direction of current flow.

To obtain the yellow would require both the red and green chips being lit at the same time. This is not really possible since the two i.e.d.'s require current flow in completely opposite directions!

However, if we were to switch the two chips on and off sufficiently quickly they will appear to be on simultaneously and the eye will perceive this as a constant yellow. Fig. 1a shows the switching waveform that may be used to achieve the three required colours.

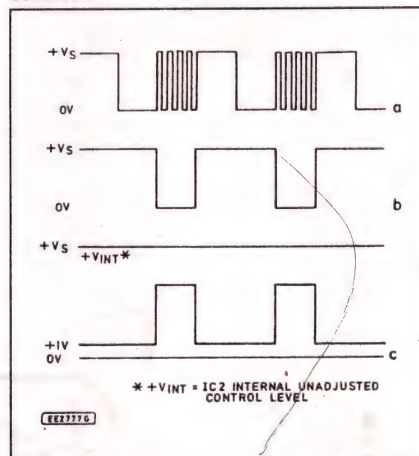


Fig. 1. Switching waveform to achieve the three colours.

CIRCUIT DESCRIPTION

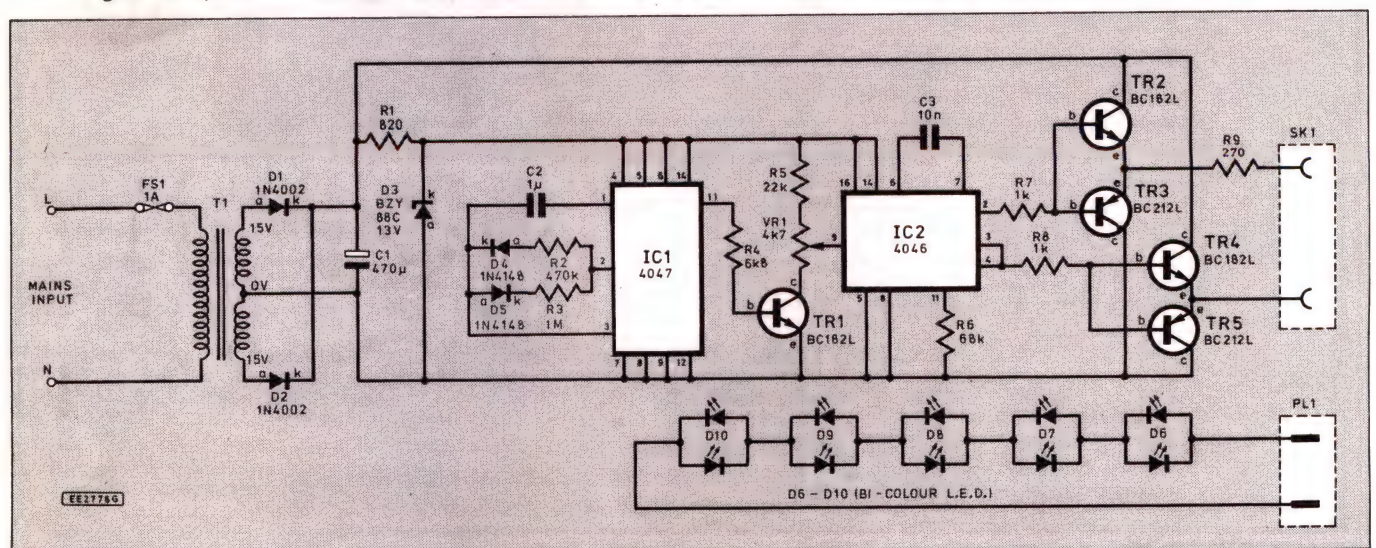
The complete circuit diagram for the Colour Changing Christmas Lights is shown in Fig. 2. Transformer T1 steps the mains voltage down to 15V-0V-15V a.c. This is rectified by diodes D1 and D2 to give a pulsating d.c. which is smoothed by capacitor C1. The smoothed d.c. is then fed into a voltage regulator circuit consisting of resistor R1 and D3, a 13V Zener diode, which provides a constant voltage for the two CMOS i.c.s. IC1 and IC2.

In this application the CMOS multi-vibrator IC1 is used in its astable mode to give a low frequency square wave output at pin 11, of the form shown in Fig. 1b. It can be seen from the diagram that the high time is approximately twice as long as the low time. This is made possible by using two different timing resistors for the two half cycles. Diodes D4 and D5 direct capacitor C2 charge and discharge currents through two separate resistors of different values in order to achieve this.

The output of IC1 at pin 11 is fed to transistor TR1 base, via resistor R4, and appears inverted at its collector which is connected to the bottom end of a potential divider, made up of VR1 and R5. The adjustable output of potentiometer VR1 provides the control voltage, shown in Fig. 1c, for pin 9 of IC2, a voltage controlled oscillator (VCO).

When VR1 is correctly adjusted the voltage at its wiper will swing between around

Fig. 2. Complete circuit diagram for the Colour Changing Christmas Lights. Fuse S1 is insulated in the mains plug.



one volt with TR1 conducting and a voltage set by the on chip potential divider when TR1 is turned off. The control voltage at pin 9 determines the output frequency of IC2 which changes from about 1Hz with the external control voltage of around one volt to 2kHz when set by the internal potential divider. Resistor R6 and capacitor C3 set the frequency range of the VCO.

The two out of phase outputs of the VCO at pin 2 and pins 3 and 4 are amplified by a pair of simple pull-push amplifier stages having unity voltage gain but a large current gain, so that several chains of series connected bi-colour l.e.d.'s may be driven. The push-pull amplifier configuration consisting of transistors TR2 to TR5 allows the bi-directional flow of current necessary to achieve the tri-colour states of l.e.d.s D6 to D10.

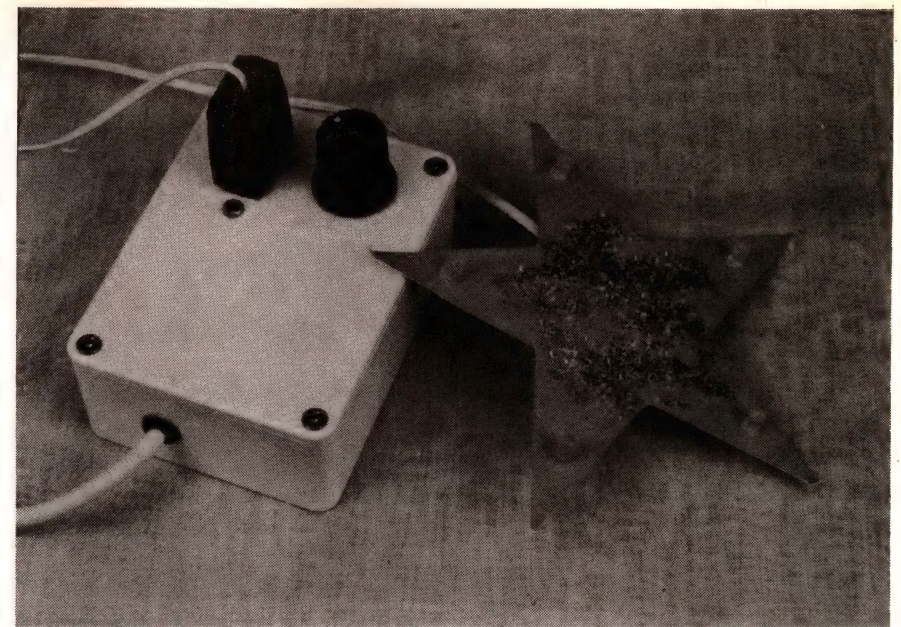
CONSTRUCTION

Most of the components are mounted on a single-sided glass-fibre printed circuit board (p.c.b.), the foil pattern and component overlay for which is shown in Fig. 3. This board is available from the *EE PCB Service*, code EE707.

It is recommended that the resistors and i.c. sockets be fitted first followed by capacitors.

It is suggested that screw terminal blocks be used for the mains connections to the board for reasons of safety (terminal blocks were also used for the l.e.d. outputs on the prototype) and these may be fitted next. Otherwise solder suitable lengths of flexible leads to the board. The three potentiometer connecting leads may be soldered directly into the board or solder pins can be used if preferred. The transformer T1 is fitted last as it makes the board heavy and awkward to work on.

Mount the p.c.b. securely in the bottom part of the case (see Fig. 4), so that it can-



The completed unit showing another suggestion for displaying the bi-colour l.e.d.s.

not move around. Make suitable holes in the lid of the box to accept VR1, SK1 and a grommet for the mains input lead. Ensure that all lid mounted components will clear the p.c.b. when the box is assembled.

Pass a length of two core mains cable through the grommet and connect to terminal block TB1. Fasten a cable tie around the mains lead inside the box to prevent its being pulled out. Wire SK1 and resistor R9 to TB2 using thin insulated leads, the polarity is unimportant since the socket is non-polarised. The last connection to be made is between VR1 and the p.c.b. and must be correctly made otherwise the unit may fail to work at all or the control will work in reverse.

IC1 and IC2 may now be fitted in their

respective sockets ensuring that they are the correct way round. Note IC2 is upside down compared to IC1. The pins may need some adjustment before they will go into the sockets. Remember these i.c.s are CMOS types and that it is possible for them to be damaged by static electricity, so avoid touching the pins with your fingers until after they have been inserted into their sockets!

Before fitting the lid tie or fasten all loose leads in place and ensure that nothing will foul when the lid is on. A plastic knob should be fitted to VR1 and a 13A plug fitted with a 1A or 3A fuse connected to the mains lead.

The strings of lights may be made up as follows: Trim the leads on five bi-colour

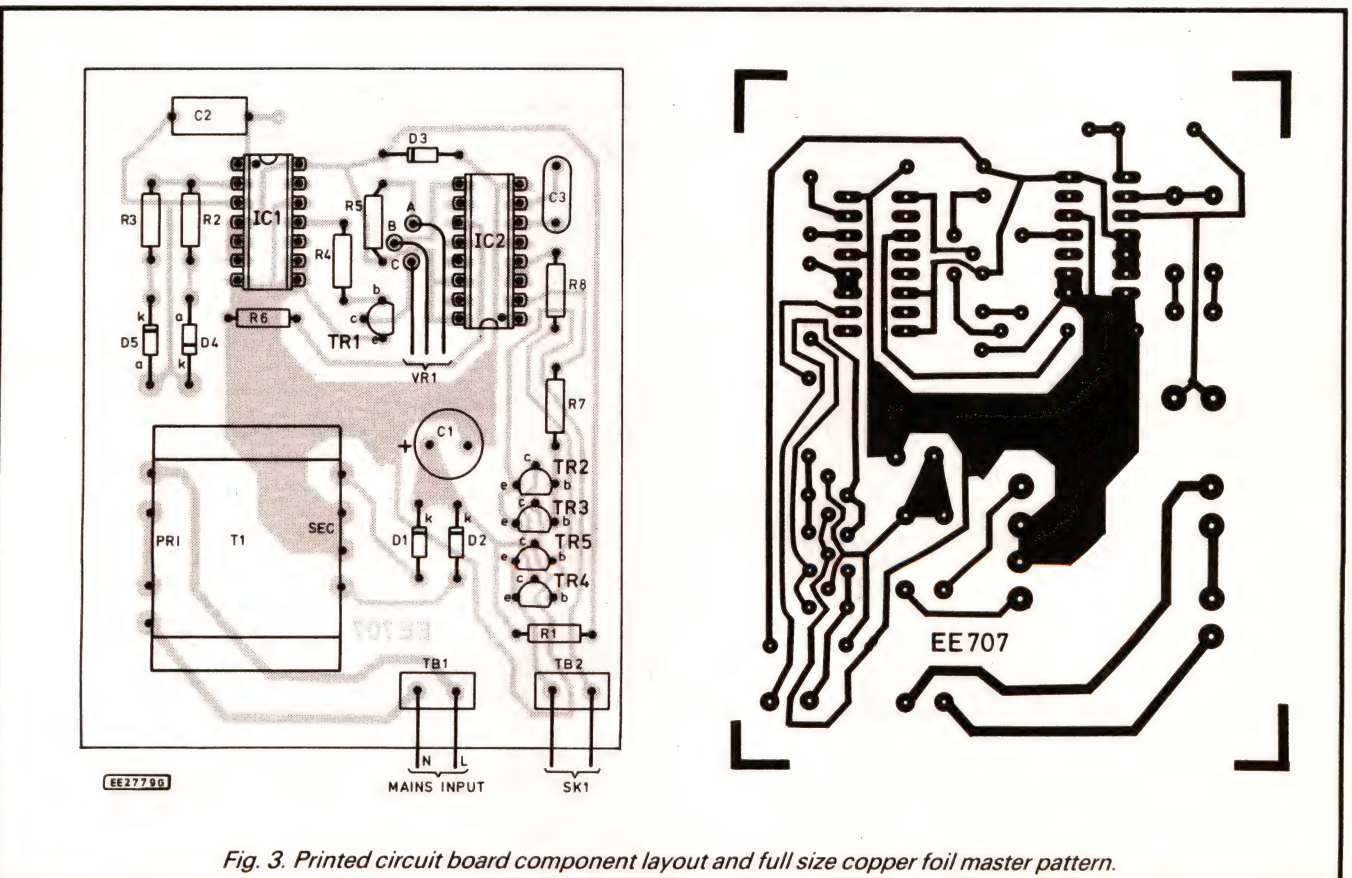


Fig. 3. Printed circuit board component layout and full size copper foil master pattern.

I.e.d.s to about 3mm and connect them up in series, observing the polarity of each one, as shown in Fig. 5 using thin single core flex. Insulate the connections on each I.e.d. using Araldite or hot adhesive from a glue gun. Connect the two free ends to PL1 and plug into the main unit.

TESTING

Commence testing by setting VR1 fully anti-clockwise. Plug into the mains and watch the I.e.d.s which should be changing colour about once a second. If nothing happens *unplug* from the mains and check that all internal wiring is correct.

COMPONENTS

Resistors

R1	820
R2	470k
R3	1M
R4	6k8
R5	22k
R6	68k
R7, R8	1k (2 off)
R9	270

All 0.25W 5% carbon

Potentiometer

VR1	4k7 rotary, lin. (plastic spindle)
-----	---------------------------------------

Capacitors

C1	470µ radial elec.
C2	1µ polyester layer
C3	10n polyester

Semiconductors

D1, D2	1N4002 1A 100V rec. (2 off)
D3	BZY88C 13V Zener
D4, D5	1N4148 signal diode (2 off)
D6-D10	bi-colour 2-pin I.e.d. (5 off)
TR1, TR2,	
TR4	BC182L npn silicon (3 off)
TR3, TR5	BC212L npn silicon (2 off)
IC1	4047B CMOS multivibrator
IC2	4046B phase locked loop

Miscellaneous

T1	Mains 3VA transformer; 15V-0V-15V sec.
SK1/PI1	Non-polarised min. 2-pin plug and socket

Printed circuit board, available from *EE PCB Service*, code 707; plastic case, size 100mm x 76mm x 41mm; mains cable; 13A 3-pin plug, with 1A or 3A fuse; plastic knob; rubber grommet; connecting wire, solder etc.

Approx cost
guidance only

£15

In particular check that the i.c.s are fitted the correct way round (it should not be possible for them to have been put in the wrong sockets since they have different numbers of pins). Check also the orientation of all semiconductors, particularly the four output transistors as it may be that two or more of these have been put in the wrong positions which will give no output at all and may destroy the transistors.

Recheck the wiring to VR1. If all is correct the unit ought to work. Replace the lid and secure with the screws before re-testing.

Once the unit is functioning correctly the I.e.d.s should be changing colour between

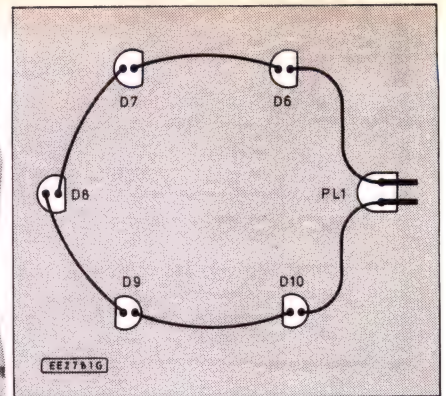
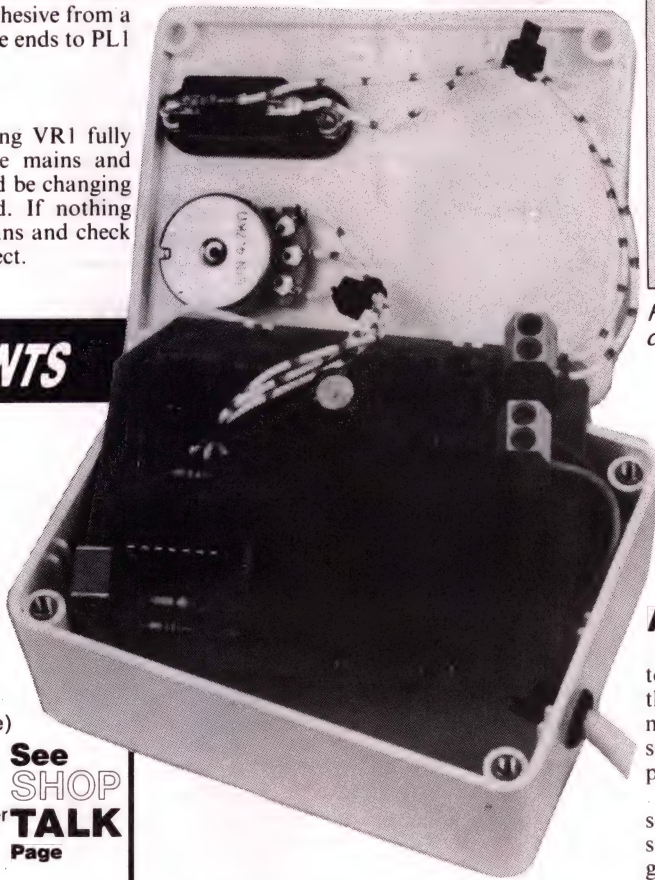


Fig. 5. Wiring up the I.e.d.s to form a display chain.

Due to mains voltage being present on the circuit board, extreme care should be exercised when carrying out work on the unit. In all cases the mains plug must be removed first.

MORE LIGHTS

Duplicating R9, SK1, PL1 and I.e.d.s D6 to D10 is all that is necessary to add up to three or four more strings of lights. Any more than this will require uprating transistors TR2 to TR5 and ultimately a larger power supply will be required.

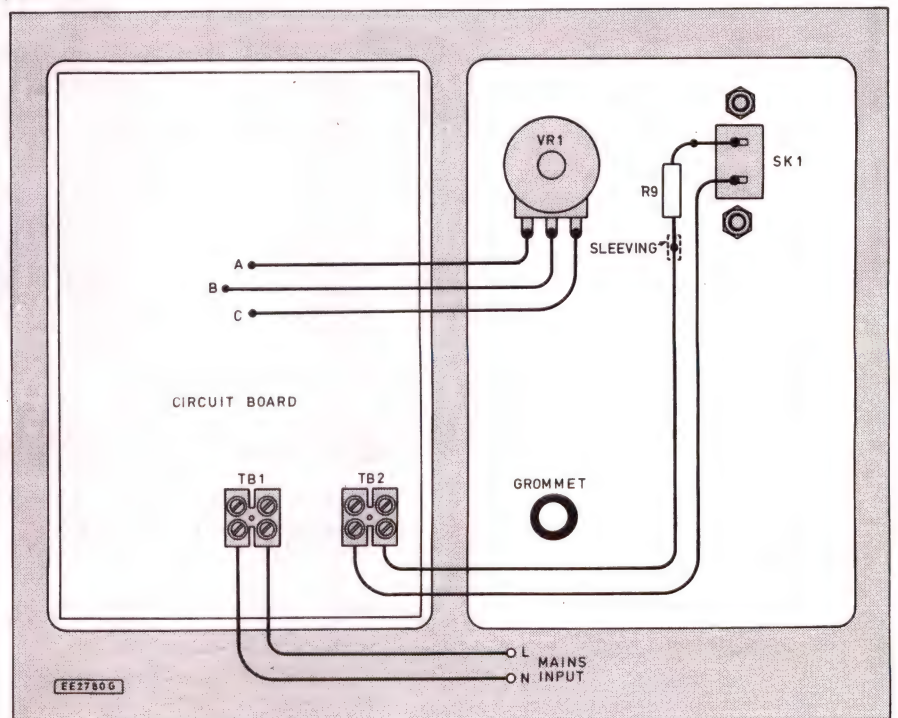
The value of resistor R9 may need some small adjustment with any number of strings connected and should be selected to give a current of 20mA or so through each I.e.d.

A variation on this circuit would be to use ordinary red and green I.e.d.s in place of the bi-colour ones. Simply connect up two strings of I.e.d.s (one of red, the other green) in the manner shown for the bi-colour set. Connect the two strings in inverse parallel and plug in to the controller. Obviously the yellow cannot be obtained, but an interesting display will result. □

yellow and either red or green. To obtain the missing colour turn VR1 slowly clockwise and the third colour should appear.

Turning VR1 further clockwise will increase the flashing rate of the red and green, leaving the yellow unaffected. Further clockwise still and the red and green will alternate fast enough to give yellow at all times.

Fig. 4. Interwiring from the circuit board to the lid mounted components.



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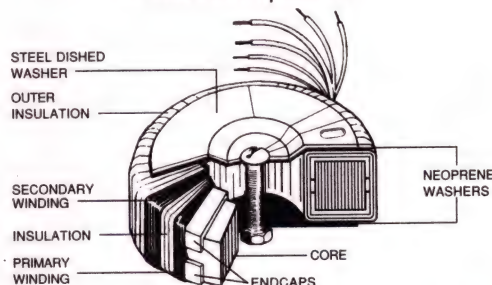
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£13.55	23011	9+9	2.77		63017	30+30	3.75
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	33014	18+18	2.22		73026	40+40	3.75
	33015	22+22	1.81		73025	45+45	3.33
	33016	25+25	1.60		73033	50+50	3.00
	33017	30+30	1.33		73028	110	2.72
	33028	110	0.72		73029	220	1.36
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	43014	18+18	3.33		83033	50+50	5.00
	43015	22+22	2.72		83042	55+55	4.54
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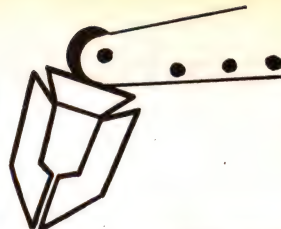
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ROBOT ROUNDUP

Nigel Clark



TWENTY YEARS AWAY

There will be no market for domestic robots for at least 20 to 25 years. There is nothing unusual in that being the view expressed by someone close to the industry. There has always been a body of opinion less optimistic, or more realistic – depending on your view – in its reading of developments in domestic robots.

However when it is expressed by the head of the company which has been given the task of taking the Department of Trade and Industry's domestic robot initiative through its next phases it has more than a good chance of becoming a self-fulfilling prophecy.

Dr Patrick Finlay, head of Fulmar Systems, backs up his view by saying that any devices which could be built today would be so expensive that only the very rich would be able to afford them.

"That will remain the case until the costs come down and the processing power increases."

However, he is not totally negative on the issue. He still thinks that there is work which can be done at the moment to help advance the day when domestic robots will become viable.

DISABLED AID

Fulmar's own suggestion is a mobile robot with an arm which could be an aid for the disabled. One critical element of the device would be that it should operate in any home environment, not requiring the house to be adapted to the needs of the robot.

This idea is now being evaluated by the DTI and Fulmar hopes to get the go-ahead soon to enable the project definition to be completed by Easter next year. The next phase would be the preparation of a demonstration prototype by the end of 1992.

Fulmar's work is taking up where Richard Pawson's Personal Robots Ltd left off when it went into liquidation towards the end of last year. In its final report on the feasibility phase of the DTI initiative it suggested four areas for further study:

- Low-cost single task device for jobs such as lawn mowing, vacuum cleaning, cooking and home security.
- Multi-function domestic robot aimed at the luxury home market.
- Domestic service industry robot.
- Healthcare robot for the handicapped.

If the Fulmar idea gets the OK from the DTI the work of preparing the prototype will be split among the members of the domestic robot initiative. As only 50 per cent of the cost of this stage will be met by the DTI the balance will have to be met from outside sources. It is expected that the initiative members doing the prototype work will fund it themselves. The final stage of producing a commercial product will get no government support at all.

VALIANT FOR CDT

Valiant Technology is determined to make its Roamer mobile an important

part of teaching Design in the National Curriculum's Craft, Design and Technology section. For most of this year, since the company decided to design a package around Roamer, Dave Catlin has been working on the project.

"It's turned into a monster," he said, adding that he hoped to have the work finished in the near future. "It's all I'm doing at the moment."

The concept was to show how the design process works, giving it a practical basis by explaining it in relation to customising Roamer, their Smartie-shaped mobile. When he began to get into the subject Catlin quickly realised that a basic idea of creating something to satisfy a need soon expands into defining a solution, creating a design, building and testing. And into those steps are inserted varying constraints such as the technology and materials available and the need to be aware that what might seem old technology could be the most relevant if adapted; for instance power from windmills is now making a comeback.

Catlin commented that, "there are certain logical steps in all this and we are hoping that this package will provide a framework to show how those steps combine to create the final product."

In the meantime Valiant has produced two new packs to enable further customising of Roamer. The light pack contains eight l.e.d.s with four different colours, two lamps and a flasher unit. An activity booklet gives some ideas of models which can be made.

The most obvious is some form of vehicle with headlights, rear lights and indicators which use the flasher unit. This unit is needed because if the flashes are programmed into Roamer they would cause the robot to stop. Another idea is to turn Roamer into a jukebox with the lights programmed to go on and off in time with the notes being played.

The sensor pack contains two touch switches, sound and light sensors and a

push button switch, increasing the design possibilities immensely. With careful programming the mobile could be made to appear as if it had a personality, reacting to changes in sound and light. Catlin even suggested it would be possible to create a form of sheepdog reacting to whistles.

Valiant's control console is also now available. Not to be confused with the control box which is added to Roamer to increase its use, the console is a stand-alone controller. It has eight inputs and eight outputs plus two stepper-motor drives and a counter unit.

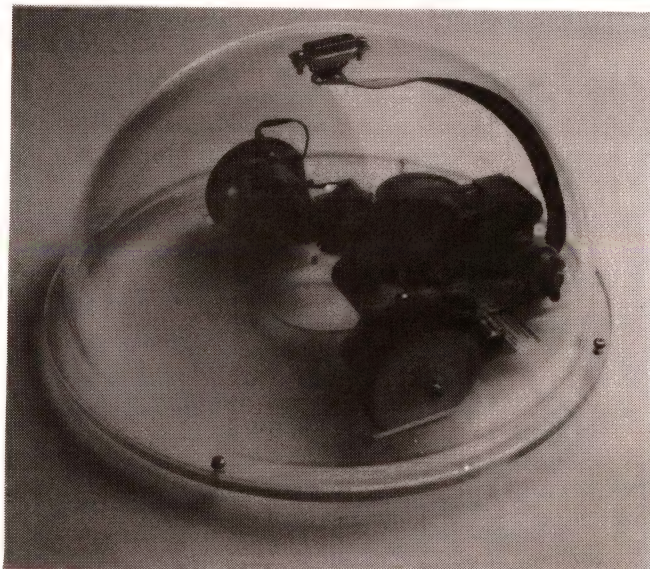
It is an upgrade of the controller on the Roamer with a number of added facilities, one of the most interesting of which is the counter. Catlin gave as an example of its capabilities a mobile which would wait until something like a light flashing on and off had occurred a set number of times before reacting.

TURTLE TRAILS

The Jessop turtle, also known as the Edinburgh turtle, the upturned mixing bowl, has had its capabilities expanded for the first time in many years with the introduction of Turtle Trails. They have been developed by MEU Cymru and are made up of printed floor mats and keyboard overlays.

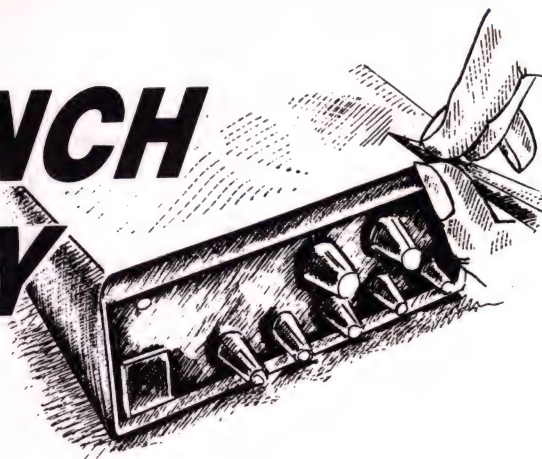
The mats contain routes for the turtles to follow and the overlays for the Concept keyboard enable the children to guide the turtle. As well as the turtle and the keyboard Logotron Logo and a Multiplexer are needed. The pack, which costs about £20, also contains instructions and templates for making other routes. Teachers' instructions and a video help provide ideas.

Jessop's turtle was one of the first on the market in this country having been developed by the Artificial Intelligence Department at Edinburgh University. It has sold steadily over the years, finding a new interest with the introduction of the National Curriculum. Costing a little more than £200 there are versions for the BBC series, Nimbus, IBM PC, Commodore C64 and Spectrum. It is driven by two stepper motors, has a retractable pen holder and uses each manufacturer's version of Logo.



The Jessop turtle is claimed to have been one of the first "mobiles" on the UK market and the new expanded version carries a price tag of just over £200.

VERSATILE BENCH POWER SUPPLY



MIKE TOOLEY BA

The first constructional project to accompany our Design Your Own Circuits, series takes the form of a Versatile Bench Power supply. This unit provides one variable output (3V to 15V) together with two fixed outputs (one of 5V and the other of 12V, both rated at 1A maximum continuous current). As with all of the practical constructional projects in this series, a number of modifications are suggested so that the more intrepid constructor can customise the unit to his or her own particular requirements.

instrumental in helping to avoid damage to circuits under test when excessive currents flow due to inadvertent misconnection or failure of individual components.

All three of the power supply outputs are protected against inadvertent short circuit connection though such a condition should not be allowed to persist for more than 60 seconds, or so.

SAFETY

It is worth stating at the outset that this project is ideal for construction by a relative beginner. The circuit is straightforward and uses relatively few components. The components themselves are quite rugged (both electrically and mechanically) and therefore do not require special handling. There is, however, one important proviso; this project derives its power directly from the domestic a.c. mains supply and thus special precautions are necessary since the mains supply (of nominally 240V at 50Hz) **can be lethal if handled incorrectly**. It is, therefore, vitally important that constructors observe the following precautions when building this project:

1. Ensure that the equipment is switched off and the a.c. mains supply lead removed whenever the equipment is

A RELIABLE bench power supply can be an extremely valuable addition to the range of test equipment available in any electronic workshop. Not only does our versatile bench power supply fulfil a general need but it can also be used to provide the various voltage rails required by the projects described in the Design series. In addition, one of the fixed voltage dual-output modules described in the text can be easily added to further extend the facilities available.

The vast majority of electronic circuits and modules operate from one or more low voltage d.c. supply rails. Indeed, the voltages and currents used by most electronic circuits are usually quite small (often less than 12V and below 1A) and none of the circuits described in our Design series require anything unusual in this respect.

OUTPUTS

Our versatile bench power supply has been designed to satisfy the need for a reliable low-voltage, low-current supply which has accurate fixed as well as variable outputs. The variable output can supply currents well in excess of 1A (its maximum continuous rating) and it has a variable current limit. This useful facility can be

Specifications

Variable output:

Voltage:	Variable from +3V to +15V
Current:	1A maximum continuous
Current limit:	Variable from 5mA to 2A max.
Regulation:	0.15% (typical)
Output resistance:	0.1 ohm (typical)
Hum and noise:	Less than 500µV

Fixed outputs:

Voltage:	+5V and +12V
Current:	1A maximum continuous (total)
Current limit:	Fixed at 1A (either output)
Regulation:	0.2% (typical)
Output resistance:	0.05 ohm (typical)
Hum and noise:	Less than 250µV

Mains input:

Voltage:	220V to 240V (see note)
Current:	200mA (typical)
Power:	50VA (maximum)

Note: The mains transformer may also be wired for 110/120V a.c. operation by parallel connecting the two primary windings. In this case the input current will typically be 400 mA.

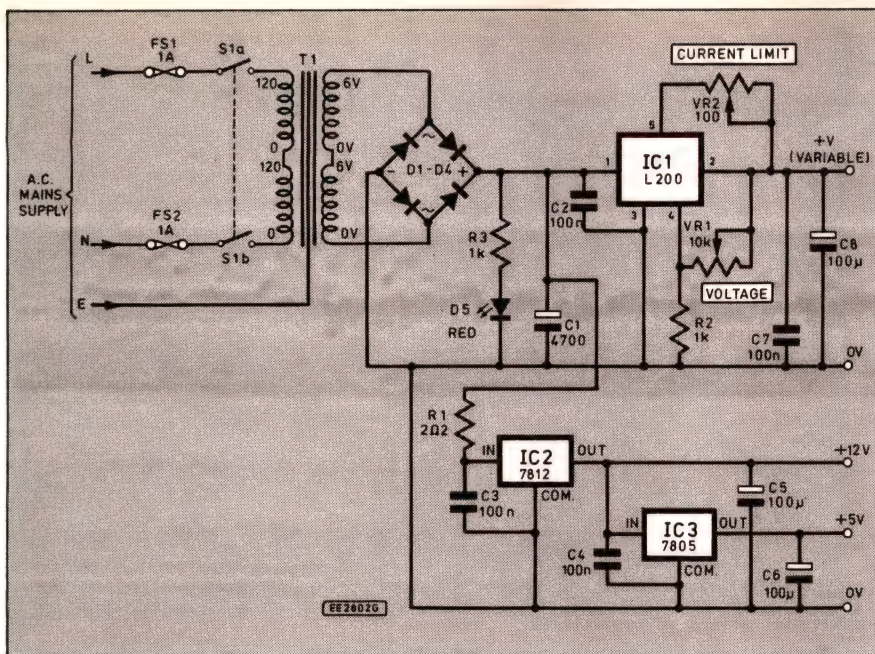


Fig. 1. Complete circuit diagram of the versatile bench power supply.

being worked on and whenever the case is in a dismantled state.

2. Ensure that only correctly rated fuses are fitted to the equipment (as specified in the components list). A standard 3A mains fuse should be fitted to the mains plug.

3. Only use the type of IEC mains lead and connector (which incorporates an earth) specified in the components list. This lead should be disconnected (and the unit switched off) whenever it is necessary to remove power from the equipment during testing and/or fault finding.

4. Do not attempt to apply mains voltage to the equipment until all of the wiring and assembly has been completed and **the wiring has been carefully checked.**

CIRCUIT DESCRIPTION

The complete circuit of the versatile bench power supply is shown in Fig. 1. The circuit is based on an L200 variable voltage regulator (IC1) and two fixed voltage regulators (IC2 and IC3) which respectively provide the fixed +12V and +5V outputs.

A conventional bridge rectifier/reservoir capacitor arrangement is used to provide a source of raw d.c. (approximately 17V off-load falling to 15V on-load) for the regulators. A low-value series resistor is incorporated in the d.c. feed to the two fixed voltage regulators in order to limit the current on full load. All three of the voltage regulators incorporate internal over-current and thermal protection.

CONSTRUCTION

The vast majority of the components for the versatile bench power supply are assembled on a single-sided printed circuit board measuring approximately $60 \times 130\text{mm}$. The copper foil layout of the printed circuit board and the corresponding component side layout are shown in Fig. 2.

Components should be assembled on the printed circuit board in the follow-

ing sequence; p.c.b. headers, resistors, capacitors, variable resistors, bridge rectifier, integrated circuit regulators. As with all of our projects, it is important to ensure that all of the components are correctly located. Furthermore, in the case of the polarised components (such as electrolytic capacitors, bridge rectifier, and integrated circuits) it is absolutely essential to ensure that each component is correctly orientated.

When construction of the printed circuit board has been completed (and before the heatsink is attached) it is well worth carrying out a careful visual check of both the upper and lower sides of the board. The upper (component) side of the printed circuit board should be examined to ensure that the components have been correctly located whilst the lower (copper track) side of the board should be checked to ensure that there are no dry joints or solder bridges between adjacent tracks. This precaution will only take a few minutes to carry out but can be instrumental in preventing much heartache at a later stage!

When assembly of the printed circuit

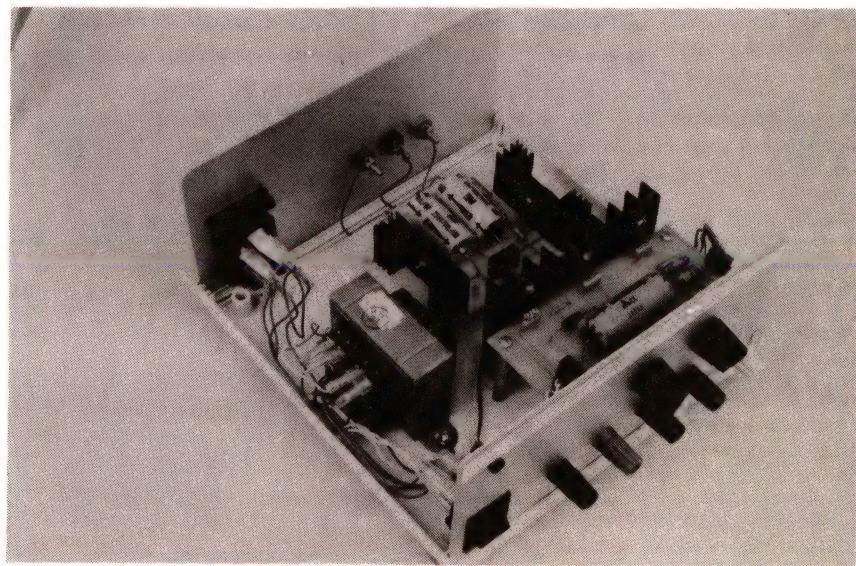
board has been completed, the board should be mounted on the front panel by means of the two threaded shafts fitted to the variable resistors. The rear of the printed circuit board is supported above the base of the case by means of two plastic or aluminium alloy mounting pillars. These must be cut to the required length (approximately 49 mm in the prototype unit) and attached by means of self-tapping No. 6 fixing screws.

HEATSINK

In order to avoid premature thermal shut-down (which would severely limit the current output capability), the three regulators require a heatsink of 3.5 degrees C per Watt (or better). This can be achieved by means of a commonly available black finished finned heatsink measuring approximately $75 \times 108 \times 14$ mm. In order to promote effective heat dissipation, the heatsink should be fitted with its fins aligned vertically and, as far as possible, in a region in which free airflow exists.

Having obtained a suitable component, the heatsink should then be aligned with the rear of the printed circuit board so that its lower edge rests on the base of the ABS case with the heat-radiating fins aligned in the vertical plane. The heatsink should be marked and carefully drilled to match the mounting holes provided in the metal tabs of the regulators, each of which should be bolted to the heatsink using an M3 nut, bolt and shakeproof washer (insulating washers and bushes are not required since the conductive mounting tabs of all three regulators are connected directly to common 0V). The bottom of the heatsink may then be attached to the base of the case by means of a small L-shaped aluminium bracket. This is also retained by means of two M3 nuts, bolts and shakeproof washers.

In order to improve thermal conductivity between the integrated circuits and the heat sink, a small film of heat sink compound should be smeared onto the rear surface of each device prior to mounting. This film can be instrumental in improving thermal conductivity between the integrated circuits and the heat sink. It is important to note that effective heat dissipation is essential in order to prevent premature thermal shut-down of the regulators. Furthermore maximum load currents can only be achieved if there is effective heat transfer from the regulators to the heat sink.



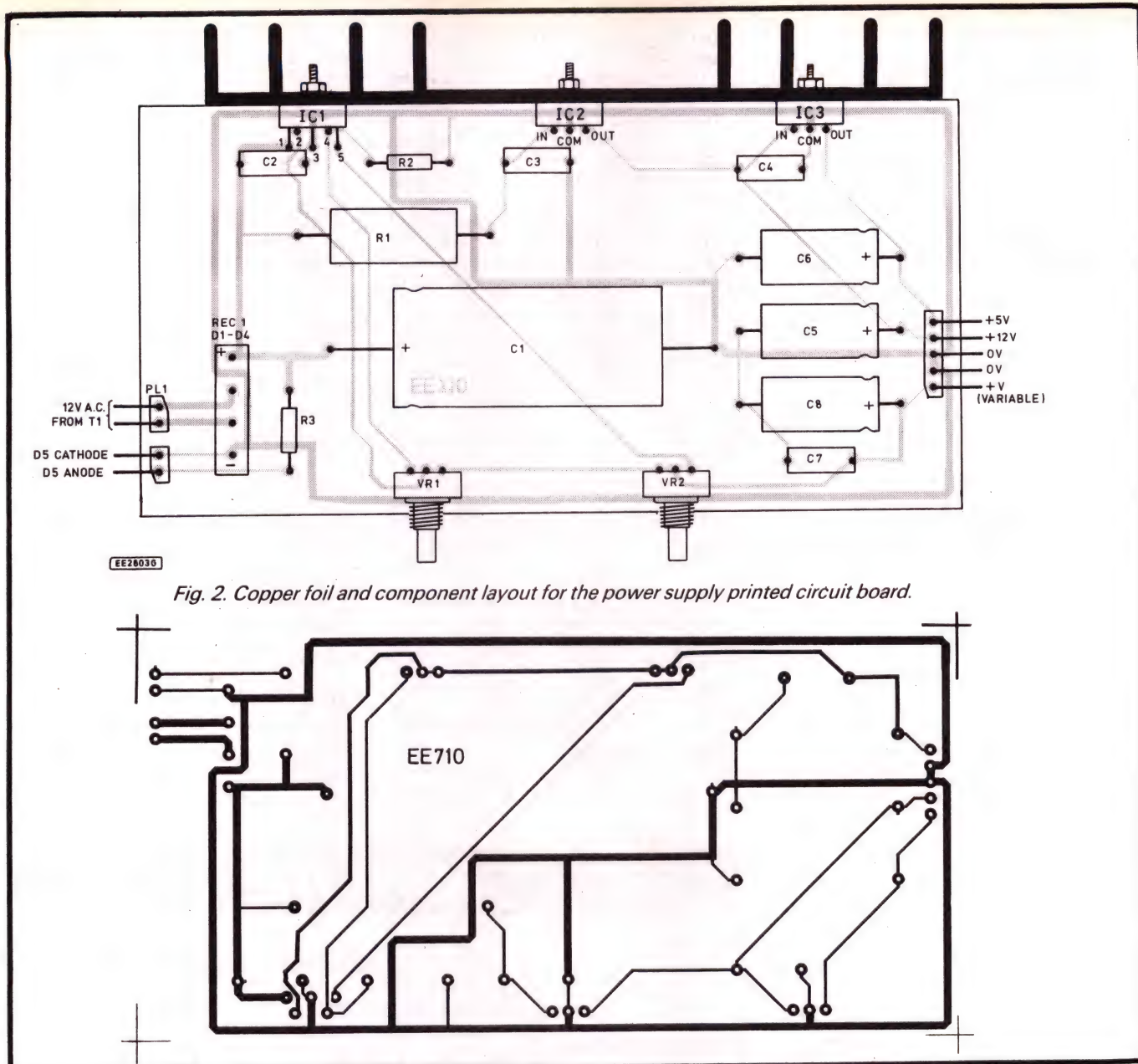


Fig. 2. Copper foil and component layout for the power supply printed circuit board.

CASE

The Versatile Bench Power Supply may be housed in any suitable ABS or metal enclosure which measures approximately 220 × 230 × 105mm or greater. Ventilation is unimportant provided there is sufficient volume of air inside the unit. If in any doubt, ventilation holes can be cut at strategic points in the underside and rear of the unit. This precaution was not found necessary on the prototype which was "soaked" for ten hours at rated output (12V 1A) in an ambient temperature of 30 degrees C.

In any event, the case should be fitted with aluminium front and rear panels to facilitate mounting of the controls, connectors and indicator. The front and rear panels should be marked out before drilling and cutting takes place. There is nothing particularly critical about the layout of the unit and constructors may wish to experiment with the location of the front panel controls and sockets.

The two controls and five output sockets all require round holes to be cut in the metal front panel. This is a fairly straightforward exercise (it is, however, worth using a centre punch so that the drill bit does not wander!) however the rear

mounted IEC mains power connector and front-panel mounted mains switch require rectangular mounting holes and are thus not quite so easy to deal with! In production applications, the required holes are normally cut using a rectangular punch but constructors are very unlikely to have access to such a tool. There is, however, no need to panic since the required apertures may be cut by means of the following simple procedure:

(a) Accurately mark out the required apertures on the aluminium front and rear panels using a ruler and sharp pencil.

(b) Carefully drill 6.5 mm (or larger) diameter holes at each corner (within the area of material to be removed).

(c) Cut, using a tension file (fitted in a hacksaw or coping saw) between the four holes and carefully remove the unwanted metal.

(d) Use a flat file to trim the metal back to the marked outline.

For reference, the dimensions (height followed by width) of the rectangular holes in the prototype unit were as follows:

IEC chassis plug and fuseholder: 48.5 × 34.5mm

Rocker-action mains switch: 27.5 × 22.5 mm

In any event, constructors are advised to check the dimensions of the components actually used prior to marking out the front and rear panels.

CONNECTORS

The IEC mains connector specified for use in this project is fitted with integral 20mm fuseholders. In the event that such a component is unavailable, a standard IEC chassis mounting plug can be used in conjunction with two separately mounted 20 mm fuseholders.

All mains connections (i.e. those associated with the IEC mains connector, fuseholders, and mains switch) are made with the aid of shrouded snap-on receptacles. This method of wiring is inherently safe (since all joints are fully insulated) and furthermore it avoids the need for soldering directly to the individual components.

Two sizes of receptacle are required: 250 (0.25 inch) for the IEC chassis connector and rocker-action mains switch and 110 (0.11 inch) for the fuseholders and transformer connections. The receptacles are assembled as follows:

(a) Select the appropriate wire colour (see below) and cut the wire to the required length.

(b) Prepare the ends of the wire by

Fig. 3. Fitting the receptacles.

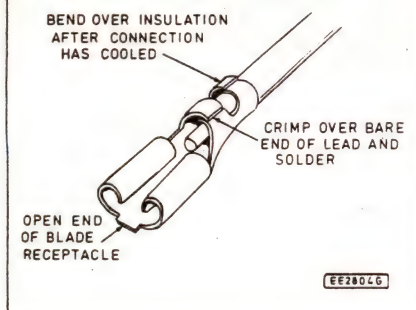
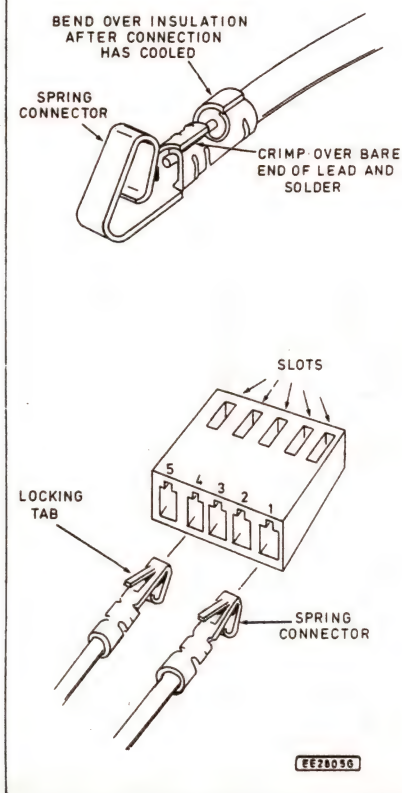


Fig. 4. Fitting the header contacts



stripping back the insulation by 3mm (110 receptacles) or 5mm (250 receptacles), twist and tin the ends.

(c) Fit receptacle covers (of appropriate sizes) to the wires (the larger open end should face towards the tinned end to which the receptacle will be fitted).

(d) Insert the tinned ends into the receptacles. Bend the receptacle to grip the tinned wire and insulation (as shown in Fig. 3).

(e) Apply heat from a soldering iron bit and run a small amount of solder into the receptacle from the open end.

(f) Slide the receptacle cover over the receptacle until it is completely insulated.

The wire used for the mains wiring should be 7/0.2mm or 16/0.2mm stranded equipment wire which conforms to BS 4808. The following colour coding is recommended:

Brown: Mains - line. Blue: Mains - neutral. Green: Mains - earth. Pink: All low-voltage a.c. wiring

Connections to the printed circuit board are made using two 5-way printed circuit board headers.

(a) Select the appropriate wire colour

(see below) and cut the wire to the required length.

(b) Prepare the ends of the wire by stripping back the insulation 2.5mm from the end. Tin the end.

(c) Insert the tinned end into the sprung contact. Bend the header contact to grip the tinned end and insulation (as shown in Fig. 4).

(d) Apply heat from a soldering iron and run a small amount of solder into contact from the spring-loaded end (take care to use the absolute minimum of solder!).

(e) Snap the receptacle into the body of the printed circuit board header (it should be gently pushed into the body of the header until it locks into place).

The wire used to make connections to the l.e.d. power indicator and 4mm screw terminals should be 1/0.6mm conforming to BS 4808. The following colour coding is recommended:

LED cathode: Black. LED anode connection: Violet. 0V/common terminals: Black. Variable output (+ve): Red. Fixed +5V output: Blue. Fixed +12V output: Yellow.

The internal wiring of the versatile bench power supply is shown in Fig. 5. It is important to carefully check the wiring of the unit before attempting to connect the power supply to the mains. Particular emphasis should be placed on the mains wiring and mains transformer connections.

TESTING

Insert two 20mm 1A quick-blow fuses into the IEC chassis plug assembly, connect an IEC mains lead (fitted with a 3A

mains fuse), and switch the unit on. The l.e.d. power indicator should become illuminated. Set both controls (VR1 and VR2) to the fully clockwise position (i.e. maximum voltage and current). Connect a voltmeter (preferably digital type) to each output in turn (the negative meter lead can be connected to either of the black 0V terminals) and measure the voltages produced. These should be within the following range:

Maximum variable output (red terminal): +15V to +17V

Fixed +5V output (blue terminal): +4.75V to +5.25V

Fixed +12V output (yellow terminal): +11.5V to +12.5V

Now set the voltage control (VR1) to minimum and again measure the voltage produced at the variable output (red terminal). This should be in the range:

Minimum variable output (red terminal): +2.4V to +3.2V.

To check the operation of the current trip, the variable output should be set to provide an output of approximately +12V. The current control (VR2) should remain set at the maximum (fully clockwise) position. Now connect a 560ohm 1/2W carbon resistor to the variable output (i.e. between the red and black terminals). Slowly back-off the current control until the output voltage starts to fall rapidly to a low value. If all is well, current limiting should occur at a position which is roughly half-way between the maximum and minimum settings. The output voltage should fall to a very low value as the setting of VR2 current control is further reduced.

If any of the output voltages are not

COMPONENTS

Resistors

R1	2Ω 2.5W vitreous coated wirewound
R2	1k 0.5W 5% carbon
R3	1k 0.25W 5% carbon

Potentiometers

VR1	10k 1W panel/p.c.b. mtg. lin.
VR2	100 1W panel/p.c.b. mtg. lin.

Capacitors

C1	4700μ axial elect. 25V
C2, C3, C4, C7	100n miniature dipped case polyester (4 off)
C5, C6, C8	100μ axial elect. 25V (3 off)

Semiconductors

BR1	200V 1.6A in-line bridge rectifier (e.g. SKB2/02L5A)
IC1	L200
IC2	7812
IC3	7805
D1	Red LED (with mounting bezel)

Miscellaneous

T1	20VA mains transformer with two secondary windings, each rated at 6V 1.6A
PL1, PL3	2-way straight p.c.b. header (0.1in pitch) (2 off)
PL2	5-way straight p.c.b. header (0.1in pitch)
SK1, SK2	5-way socket housing (0.1in pitch) (2 off)
FS1, FS2	20mm 1A quick-blow fuses (2 off)
S1	DPST snap-fit rocker-action mains switch

Heatsink, 3.5deg. C/W finned black heatsink approx. 75 x 108 x 14mm (see text); Enclosure, ABS enclosure (220 x 230 x 105 mm) with aluminium front and rear panels; knobs, Styled grub screw fixing knobs with pointers (2 off); terminals, insulated 4mm terminals (1 red, 2 black, 1 blue, 1 yellow); receptacles, (7 off) 110 (0.11in) receptacles (10 off) 250 (0.25in) receptacle covers (7 off) 110 (0.11in) receptacle covers (10 off); mains plug, double fused snap-in IEC chassis plug; printed circuit board (see text) available from the *EE PCB Service*, order code EE710; pillars plastic or aluminium alloy (see text) with self-tapping No. 6 fixing screws (4 off)

Approx cost
guidance only

£30 plus case

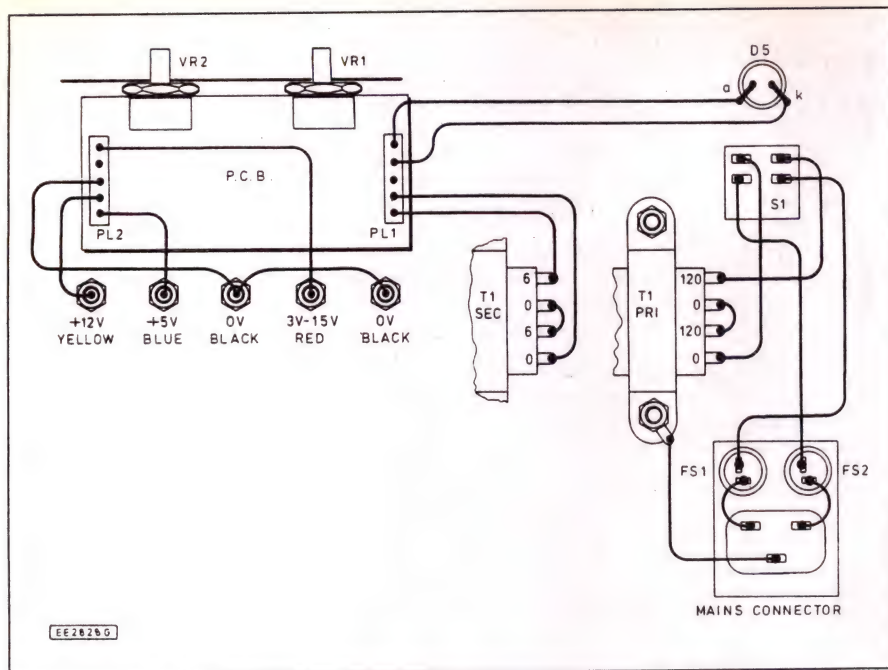


Fig. 5. Internal wiring of the versatile bench power supply.

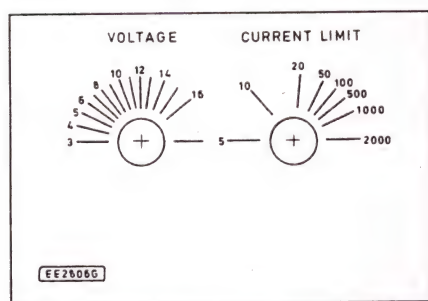


Fig. 6. Front panel calibration marks.

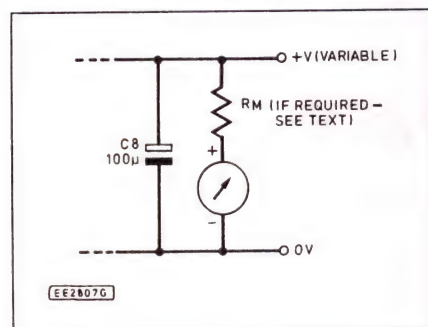


Fig. 7. Connecting a voltmeter to the variable output

within the ranges specified or if the variable output current limit fails to operate as described, it is best to switch off and disconnect the mains power before carefully checking the printed circuit board and internal wiring.

MODIFICATIONS

A number of useful modifications may be made to the basic power supply design. The suggestions made here are provided as "food for thought" and should make a starting point for further development. Constructors are invited to report their own modifications to be incorporated in the Readers' Feedback which will appear in the final part of our Design series.

Additional fixed dual-voltage outputs

The ability to provide dual-voltage outputs (i.e. outputs of identical voltage but of opposite polarity) can be an extremely useful additional facility when dealing with

equipment which requires split power supply rails (such as $\pm 5V$, $\pm 9V$ or $\pm 12V$). This facility can easily be added to the versatile bench power supply and, in order to support the necessary modification, sufficient space has been left to accommodate a fixed dual-voltage module at the rear of the unit.

The outputs provided by this module can easily be made available via 4 mm screw-terminals fitted to the rear panel whilst the required low-voltage a.c. input ($2 \times 6V$) can be derived from the existing mains transformer (the centre-tap link is taken to the 0V connection on the dual-voltage module). It is important to note that, since the fixed and variable power supply modules are not electrically isolated when a common low-voltage a.c. supply is used, the 0V connections should remain separate (i.e. there should be no direct connection between the two modules).

Increased output voltage capability

In some circumstances, the maximum

variable output voltage of $+15V$ can be considered something of a limitation. Indeed, under full-load, the output voltage may fall to somewhat less than this value. In order to increase the maximum output voltage to around $22V$, the following modifications are required:

- Replace the mains transformer, T1, with a suitable rated (30VA, or greater) component with two secondary windings, each rated at $9V$ $1.6A$ (or greater).
- Replace C1 (4700μ $25V$) by a 4700μ axial lead electrolytic rated at $35V$ (or greater).
- Replace C8 (100μ $25V$) by a 100μ axial lead electrolytic rated at $35V$ (or greater).
- Replace R1 (2.2Ω $2.5W$) by a 4.7Ω vitreous coated wirewound component rated at $6W$.
- Replace the heatsink (3.5 degrees C per Watt) by a similar unit rated at 3 degrees C per Watt (or less).

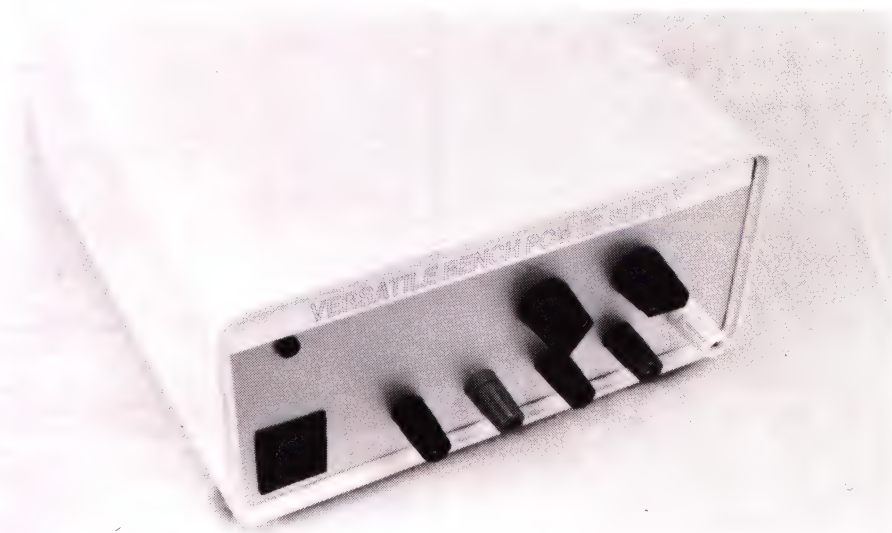
Adding a voltmeter

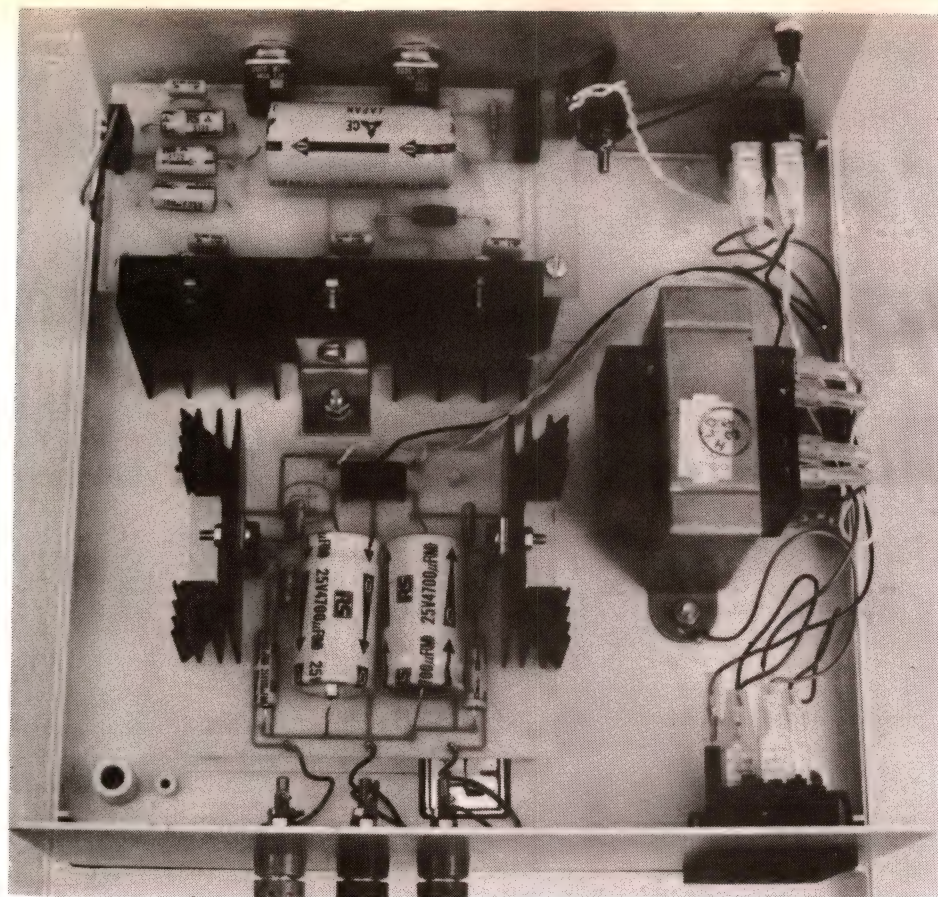
Rather than rely on the front panel calibration marks, a meter can usefully be added to display the output voltage produced by the variable output of the power supply. An analogue meter (based on a moving coil movement) can simply be connected in parallel with the output terminals. If a meter calibrated directly in "volts" is available, it should have a full-scale reading of either $20V$ or $25V$. Such an instrument will generally incorporate the necessary series multiplier resistor and thus no external component will be required. If, on the other hand, a meter calibrated in " μA " or " mA " is to be used, it will require a series resistor (see Fig. 7) the value of which can be determined from the following formula:

$$R = \frac{V}{I_{FS}} - R_M$$

where V is the full-scale deflection voltage (e.g. $20V$), I_{FS} is the full-scale deflection current and R_M is the resistance of the moving coil.

I_{FS} will typically be $50\mu A$, $100\mu A$ or $1mA$ and the meter scale will have to be modified so that appropriate increments of voltage (rather than current) are indicated. This is not a particularly arduous task since most meter scales are removable and rub-





An additional $\pm$ fixed output board can easily be added as shown above.

down transfers can be carefully applied to produce a professional finish.

As an example and assuming that a 1mA meter movement having an internal coil resistance of 200ohm is to be employed, the required value of series multiplier resistor will be:

$$R = \frac{20V}{1mA} - 200 \text{ ohms}$$

$$\text{thus } R = 20k - 0.2k = 19.8k$$

This value can be realised by connecting an 18k resistor in series with a 1k8 resistor. Both resistors should be close tolerance $\pm 5\%$ (or better) types.

As an alternative to the use of an analogue meter and at a little additional expense, a digital panel meter module can be used. These are available in two forms with either l.e.d. and l.c.d. displays and require a separate supply voltage of +5V (l.e.d.) or typically +7.5V to 15V (l.c.d.).

In the first case, the supply may be taken from the fixed +5V power supply output whilst in the latter case the supply may be derived from the +12V fixed output. Modules are usually provided with comprehensive connecting instructions. It is perhaps worth stating that the l.e.d. types offer very much improved readability under poor lighting conditions and thus can readily justify the slightly higher cost.

Front panel mounting of either an analogue meter movement or a digital panel meter module should prove to be reasonably straightforward and an area of no more than about 60 x 46mm (analogue meter) or 72 x 36mm (digital meter module) will be required. $\square$

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EVERYDAY ELECTRONICS

JANUARY ISSUE ON SALE 7TH DECEMBER 1990



12V LAMP/VACUUM CLEANER CHARGER

T. R. de VAUX-BALBIRNIE

A lamp or vacuum cleaner charger for the family on the move

SMALL rechargeable lamps and vacuum cleaners of the Black & Decker "Dustbuster" type are very popular. These contain nickel-cadmium batteries which are kept charged from the mains using a small plug-in unit. Such lamps and vacuum cleaners are useful for general jobs inside the car, caravan or boat. However, on trips away from home where no mains supply is available, they are of limited use. This is because the operating time available from one charge is quite short.

OPERATION

The present circuit temporarily replaces the existing mains unit and enables charging to be effected from a 12V d.c. source (car battery). The appliance may then be kept charged from the car system or from a caravan or boat supply. The lamp or vacuum cleaner may then be used just as it is at home.

The unit may be used to charge lamps, vacuum cleaners or other appliances operating from up to 8 cells (nominally 9.6V). It may also be used as a "straight" general purpose nickel-cadmium battery charger. No modification is made to the lamp or vacuum cleaner itself – apart from

fitting an additional socket – so mains charging may be resumed at any time.

The 12V Lamp/Vacuum Charger is very straightforward to construct but note that a milliammeter (or multi-tester) will be needed at the setting-up stage. This can probably be borrowed if one is not owned – an inexpensive one will be quiet good enough for the purpose since high accuracy is not required. Since the metal case is connected to the negative supply, the device is **suitable for negative-earth systems only**.

The charger has a three-position switch providing "off", "trickle" and "boost" charging. The "boost" setting will bring totally discharged batteries back to full charge in approximately 16 hours. No harm will result if the switch is left in this position continuously but this practice is thought to reduce the life of the batteries somewhat and wastes power.

The "trickle" setting will normally be used for continuous charging. The load of 10mA approximately here imposes negligible drain on the charging battery. The circuit is fitted with a fuse which will guard against circuit failure accompanied by gross overcharging.

Nickel-cadmium batteries (Ni-Cads) require constant current charging. The cir-

cuit must therefore be designed to provide a steady output current despite quite wide variations in the operating voltages. Thus, as the terminal voltage of the nickel-cadmium cells rises or when the input voltage changes, correct charging will be maintained.

CIRCUIT DESCRIPTION

The circuit for the 12V Lamp or Vacuum Charger is shown in Fig. 1. S1 is a 4-pole 3-position slide switch but only two poles are used in this application – poles A and B. It would be possible to use a two-pole rotary switch instead. Alternatively, two two-position slide switches – one to select charging mode and the other for on-off switching could be used. In this circuit, pole B is responsible for on-off switching while pole A provides circuit changes for trickle/continuous settings.

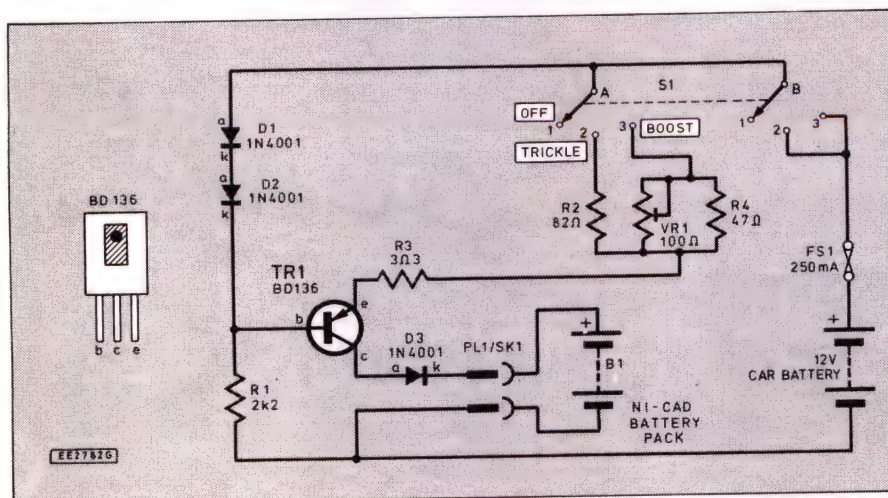
With S1 in position 1 (OFF), the supply positive feed is disconnected from the rest of the circuit. In position 2 (TRICKLE) and 3 (BOOST), pole B connects the supply. Current now flows through diodes D1 and D2 connected in series and through resistor, R1. Since a forward biased silicon diode develops 0.7V approximately between its ends, there will be 1.4V appearing between the base of transistor TR1 and the positive supply line.

Note that TR1 is a *pn*p transistor rather than the more usual *npn* type. The emitter of TR1 has resistor, R3, and either resistor, R2, or the network consisting of fixed resistor R4 connected in parallel with preset, VR1, connected to the positive supply line according to whether S1 is in position 2 (TRICKLE) or 3 (BOOST).

With TR1 carrying base current via R1, the transistor is biased on and approximately 0.7V will appear between base and emitter. There will therefore be approximately 1.4V – 0.7V = 0.7V appearing between TR1 emitter and the positive supply line. By selecting suitable values for R2, R3, R4 and VR1 the current flowing may be controlled.

The emitter current is the sum of the collector current and base current but since the base current is small, the collector and emitter currents are virtually the same. The nickel-cadmium battery pack, B1, is connected in the collector circuit through plug and socket, PL1/SK1, so its charging current is practically the same as the emitter current. Diode, D3, prevents current possibly draining from the nickel-cadmium cells into the rest of the circuit if S1 is switched off.

Fig. 1. Complete circuit diagram for the 12V Lamp/Vacuum Cleaner Charger.



CHARGING CURRENT

Suppose a charging current of 120mA is required (a typical value) with the circuit on BOOST. Using Ohm's Law for the emitter resistance: $R = V/I = 0.7/0.12 = 6$ ohms approximately. Since R3 is fixed at 3Ω, VR1 will need to be adjusted to 3 ohms approximately. The meter referred to earlier will be needed to get this figure right since the predicted value may vary by a small margin from the theoretical one. The value of resistor, R2, sets the trickle current to 8mA approximately and no adjustment is allowed for here since its value is not critical.

The predicted current will flow through B1 so long as its total nominal voltage over that of the supply is developed between TR1 collector and emitter. For example, suppose the battery pack is rated at nominal 4.8V (four cells) and the supply is 12V. 0.7V appears across the emitter resistor as explained previously. A further 0.7V is developed across D3 and 4.8V across the battery pack itself. The total excess voltage is therefore $12 - (0.7 + 0.7 + 4.8) = 5.8V$. This will appear between TR1 collector and emitter and will vary during the course of charging to maintain a stable operating current. This will take account of the terminal voltage of B1 rising as the cells charge and variations in the supply voltage.

Transistor TR1 will dissipate power as the product of the voltage between collector and emitter and the current flowing. This will appear as heat. Even if the output terminals were short-circuited, the current as calculated would still flow but now the maximum excess voltage (nominally 10.6V) would appear between collector and emitter. More heat would therefore be

COMPONENTS

Resistors

R1 2k2
R2 82
R3 3Ω3
R4 47

All 0.25W 5% carbon.

Potentiometer

VR1 100 sub-miniature horiz. preset.

Semiconductors

TR1 BD136 pnp silicon
D1 to D3 1N4001 silicon (3 off)

Miscellaneous

S1 4-pole 3 position slide switch - (see text)
FS1 20mm.chassis fuseholder and 250mA quick-blow fuse to suit.

Stripboard 0.1 in. matrix, size 13 strips x 11 holes; aluminium box size 76 x 51 x 25mm; T0126 mounting kit; rubber grommets (2 off); adhesive fixing pads; 2.1mm power in plug and socket to suit; two-core stranded wire; "rainbow" ribbon cable; self-adhesive plastic feet (4 off).

See SHOP TALK Page

Approx cost guidance only **£7**

produced. TR1 is of a type normally used for audio amplifier applications - in some ways the present circuit behaves like an amplifier with the transistor operating somewhere between cut-off and saturation.

PRE-CONSTRUCTION CHECK

Before commencing construction of the main unit, the appliance must be partly dismantled to fit the power-in socket. It is also necessary to determine the number and type of cells inside. This is usually a simple matter of removing a few self-tapping screws which hold the two halves of the case together. Any number of cells up to eight is satisfactory four being common.

While inspecting the cells, take note of their size (height and diameter) and whether any additional circuitry exists inside the case. If there is additional circuitry, apart from the lamp motor and on-off switch, it will be as well to abandon the project. However, it may be possible to use the "break" contacts on the power-in socket to isolate it when the plug is inserted. A typical arrangement is shown in Fig. 2.

Look for a free space for the power-in socket (perhaps in the handle as in the prototype - see photograph), drill a hole and mount it. Note that the single hole mounting type gives a neater appearance than the two-hole fixing variety. Check that the internal batteries are connected direct to the mains charger connector and connect the new socket direct to these using light-duty twin stranded wire. Alternatively, make the connections direct to the solder tags on the batteries themselves.

Take note which connection is the positive one so that the new charger will be connected with the correct polarity later. This is essential as damage will be caused if it is connected to the nickel-cadmium cells in the wrong sense. When this work has been checked, the unit may be re-assembled.

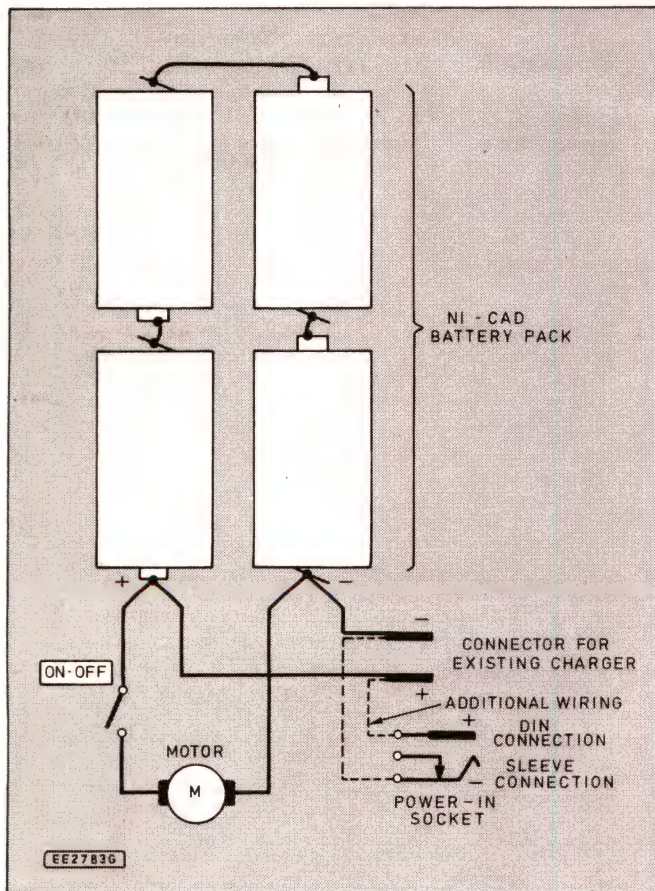
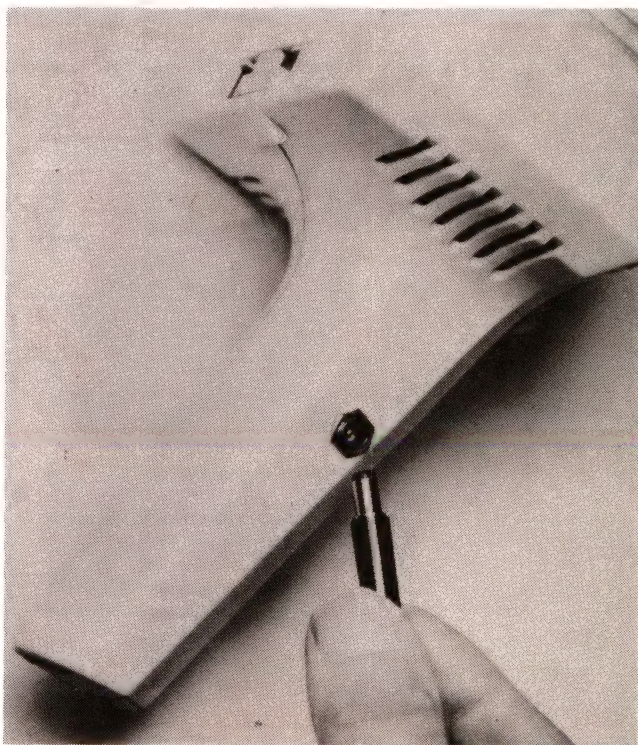


Fig. 2 (left). Adding a power-in socket to the existing low voltage vacuum cleaner.

(below). The power-in socket installed in the handle of the appliance.



CONSTRUCTION

The circuit is built chiefly on a piece of 0.1 in. matrix stripboard, size 13 strips x 11 holes (see Fig. 3). Begin by cutting this to size, drilling the single mounting hole and make the track breaks and inter-strip link. After a careful check for errors, the soldered on-board components should be added. Take care over the polarity of the three diodes. Solder 8 cm pieces of light-duty stranded wire connecting to wire copper strips A, C, D, E, F, G, I and L as indicated. Using different coloured wires e.g. "rainbow" ribbon cable here will help in avoiding wiring errors.

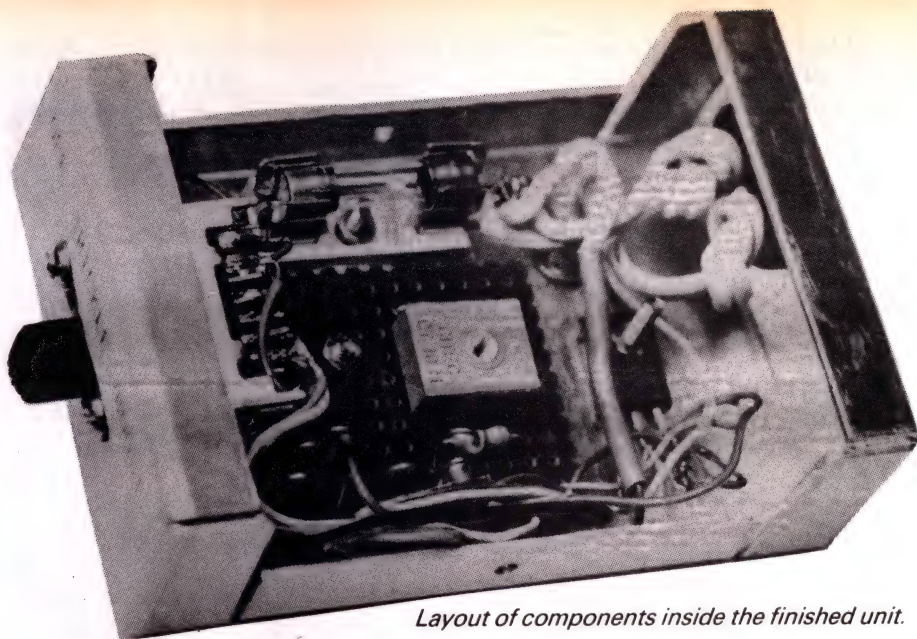
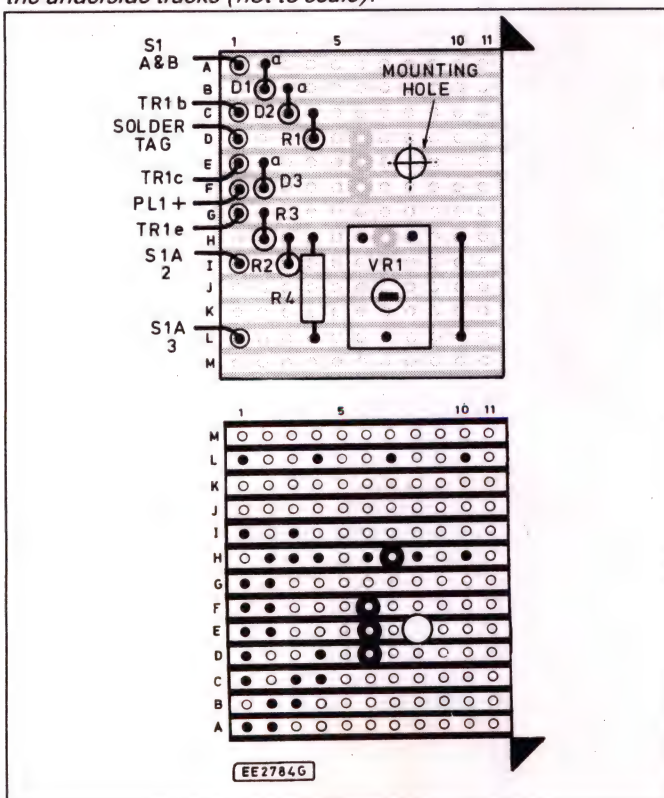
Note: Since the case is used as a heatsink for transistor TR1, an aluminium box must be used.

Drill holes in the box for input and output leads also for S1, FS1, TR1, circuit panel and solder tag mounting. Fit rubber grommets in the input/output lead holes. Mount S1 – some packing will be needed between the body and case so that the plastic slider does not protrude too far on the outside.

Mount all remaining components but do not attach the circuit panel yet. Complete the internal wiring (see Fig. 4) noting that TR1 must be attached using a mounting kit. This will isolate it from the metalwork electrically yet allow the free flow of heat. Note that S1 wiring refers to the particular type of switch used in the prototype unit. This may need to be modified to suit the particular switch or switches being used.

Input and output leads consist of pieces of light-duty twin stranded wire. Figure-of-8 loudspeaker wire is ideal since one wire is striped and this may be used to denote the positive one. Put strain relief clamps on the input and output leads inside the case to prevent them from pulling free in service. Note the connection between the wire leading from strip F on the circuit panel and the positive output lead. This joint must be properly sleeved to prevent short-circuits.

Fig. 3. Stripboard component layout and details of breaks in the underside tracks (not to scale).



Layout of components inside the finished unit.

Place three or more adhesive fixing pads on the copper strip side of the circuit panel. These will keep all connections well clear of the metalwork when it is in position. Attach the panel securely using an 8BA fixing through the hole drilled for the purpose. Insert the fuse into its holder. Note that all components are mounted on the base section of the box with nothing on the lid. Fit the base of the case with self-adhesive plastic feet. Switch S1 "off" and leave VR1 adjusted fully anticlockwise.

TESTING

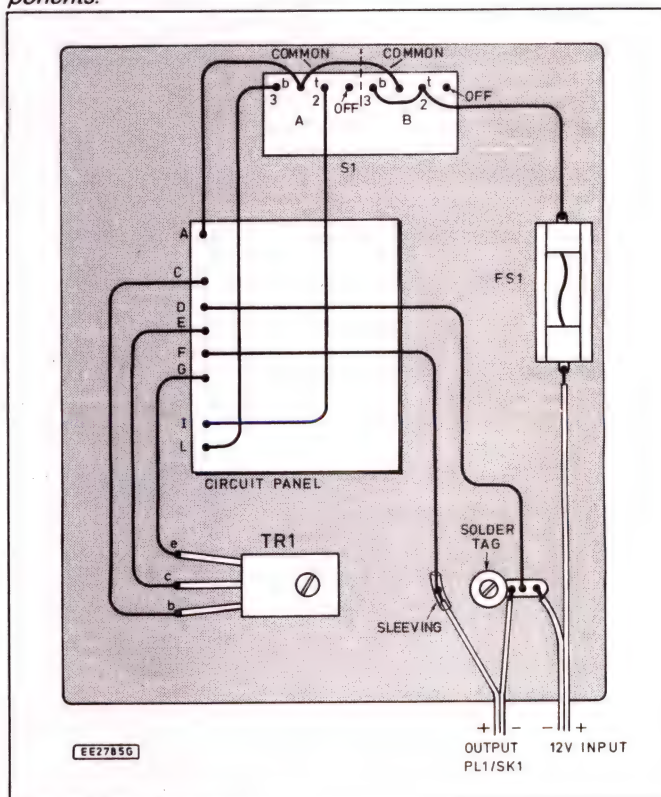
Make a basic test by connecting the output wires direct to the milliammeter observing the polarity. If a multimeter is being used for this purpose, it should be set to a d.c. current range of not less than 250mA full-scale deflection. Connect the input wires to the supply, again, observing the polarity. For this test, a 9V PP9 battery in good condition will do.

Switch S1 to "TRICKLE". A current in the region of 10mA should be indicated. Now switch to "BOOST". The meter should read about 10 to 20mA which may be increased by rotating VR1 clockwise. Do not exceed 200mA – although it may be impossible to reach this figure anyway. Set the current to the correct value.

If "C" size cells are used (27mm high x 49mm diameter) then 150 to 200mA would be correct. Sometimes specialist sizes are used – the Dustbuster uses so-called "RR" cells 42mm high x 23mm diameter) and here 100 to 120mA would be appropriate. Where "AA" cells are used (50mm high x 14mm diameter) then 30-40mA is suitable.

Solder the output wires to the power-in plug. Fit the input wire with a plug appropriate to the existing installation. The switch may now be labelled, the case assembled – checking for trapped wires – and the unit put into service. □

Fig. 4. Interwiring from the circuit board to all off-board components.



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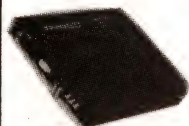
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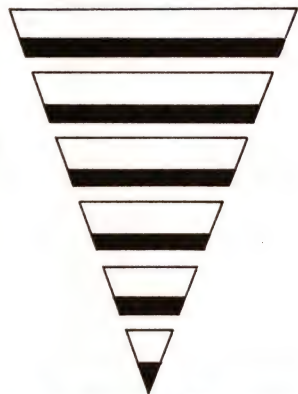
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AA532	9p	BD238	24p	2114	200p
AC107	40p	BD239	30p	2532	330p
AC125	25p	BD240	40p	2716	200p
AC126	25p	BD243A	50p	2732	280p
AC127	21p	BD244	50p	2732A	300p
AC128	21p	BD245	50p	2764	240p
AC128K	21p	BD246	50p	27C64	550p
AC141K	30p	BD267	45p	27128	310p
AC142K	30p	BD268	45p	27256-25	400p
AC176	22p	BD269	45p	41256-15	240p
AC176K	22p	BD270	45p	4116	75p
AC180	22p	BD311	100p	4164-15	150p
AC187K	21p	BD312	100p	6116	150p
AC188	21p	BD313	100p	6264-12	300p
AC188	21p	BD314	100p	6502	400p
AC188	21p	BD315	150p	65C02	930p
AC188	21p	BD316	150p	6503	570p
AD149	60p	BD317	150p	6520	170p
AF124	50p	BD318	150p	6522	330p
AF125	50p	BD331	40p	6532	480p
AF126	50p	BD332	40p	6551	530p
AF127	50p	BD361	60p	6800	210p
AF139	30p	BD362	60p	6802	220p
AF239	30p	BD370	30p	6803	800p
AF379	40p	BD371	40p	6808	500p
BA145	10p	BD401	40p	6809	600p
BA148	10p	BD433	28p	6810	150p
BA154	6p	BD434	30p	6818	380p
BA157	12p	BD435	31p	6820	140p
BB105B	18p	BD436	30p	6821	140p
BB205B	24p	BD437	30p	6840	310p
BC107	8p	BD438	38p	6854	620p
BC108	8p	BD439	40p	6880A	400p
BC109	8p	BD440	40p	6885A	300p
BC109C	10p	BD441	40p	6886	500p
BC115	10p	BD442	40p	6888	500p
BC118	11p	BD443	40p	6889	500p
BC140	20p	BD444	40p	6891	500p
BC141	20p	BD445	40p	6892	500p
BC142	20p	BD446	40p	6893	500p
BC143	20p	BD447	40p	6894	500p
BC147	8p	BD448	40p	6895	500p
BC148	8p	BD449	40p	6896	500p
BC149	8p	BD450	40p	6897	500p
BC157	8p	BD451	40p	6898	500p
BC159	8p	BD452	40p	6899	500p
BC160	30p	BD453	40p	6899A	500p
BC171	10p	BD454	40p	6899B	500p
BC172	10p	BD455	40p	6899C	500p
BC177	14p	BD456	40p	6899D	500p
BC178	14p	BD457	40p	6899E	500p
BC179	14p	BD458	40p	6899F	500p
BC182	7p	BD459	40p	6899G	500p
BC182L	7p	BD460	40p	6899H	500p
BC183	7p	BD461	40p	6899I	500p
BC183L	7p	BD462	40p	6899J	500p
BC184	7p	BD463	40p	6899K	500p
BC184L	7p	BD464	40p	6899L	500p
BC212	7p	BD465	40p	6899M	500p
BC212L	7p	BD466	40p	6899N	500p
BC213	7p	BD467	40p	6899O	500p
BC213L	7p	BD468	40p	6899P	500p
BC214	7p	BD469	40p	6899Q	500p
BC214L	7p	BD470	40p	6899R	500p
BC237	7p	BD471	40p	6899S	500p
BC238	7p	BD472	40p	6899T	500p
BC239	7p	BD473	40p	6899U	500p
BC300	20p	BD474	40p	6899V	500p
BC301	20p	BD475	40p	6899W	500p
BC302	20p	BD476	40p	6899X	500p
BC303	20p	BD477	40p	6899Y	500p
BC304	20p	BD478	40p	6899Z	500p
BC308	10p	BD479	40p	6899A	500p
BC327	10p	BD480	40p	6899B	500p
BC328	7p	BD481	40p	6899C	500p
BC337	7p	BD482	40p	6899D	500p
BC338	7p	BD483	40p	6899E	500p
BC441	28p	BD484	40p	6899F	500p
BC446	8p	BD485	40p	6899G	500p
BC449	8p	BD486	40p	6899H	500p
BC461	28p	BD487	40p	6899I	500p
BC477	18p	BD488	40p	6899J	500p
BC478	18p	BD489	40p	6899K	500p
BC479	18p	BD490	40p	6899L	500p
BC489	20p	BD491	40p	6899M	500p
BC490	20p	BD492	40p	6899N	500p
BC516	22p	BD493	40p	6899O	500p
BC528	22p	BD494	40p	6899P	500p
BC537	22p	BD495	40p	6899Q	500p
BC546	8p	BD496	40p	6899R	500p
BC547	8p	BD497	40p	6899S	500p
BC548	8p	BD498	40p	6899T	500p
BC549	8p	BD499	40p	6899U	500p
BC550	8p	BD500	40p	6899V	500p
BC556	8p	BD501	40p	6899W	500p
BC557	7p	BD502	40p	6899X	500p
BC558	8p	BD503	40p	6899Y	500p
BC559	8p	BD504	40p	6899Z	500p
BC560	8p	BD505	40p	6899A	500p
BC637	20p	BD506	40p	6899B	500p
BC638	20p	BD507	40p	6899C	500p
BC639	20p	BD508	40p	6899D	500p
BC640	20p	BD509	40p	6899E	500p
BCV32	200p	BD510	40p	6899F	500p
BCV33	200p	BD511	40p	6899G	500p
BCV34	200p	BD512	40p	6899H	500p
BCV70	16p	BD513	40p	6899I	500p
BCV71	16p	BD514	40p	6899J	500p
BD115	16p	BD515	40p	6899K	500p
BD124P	50p	BD516	40p	6899L	500p
BD124	110p	BD517	40p	6899M	500p
BD131	25p	BD518	40p	6899N	500p
BD132	25p	BD519	40p	6899O	500p
BD133	25p	BD520	40p	6899P	500p
BD136	20p	BD521	40p	6899Q	500p
BD137	20p	BD522	40p	6899R	500p
BD138	20p	BD523	40p	6899S	500p
BD139	20p	BD524	40p	6899T	500p
BD140	20p	BD525	40p	6899U	500p
BD141	20p	BD526	40p	6899V	500p
BD142	20p	BD527	40p	6899W	500p
BD150	38p	BD528	40p	6899X	500p
BD157	38p	BD529	40p	6899Y	500p
BD158	38p	BD530	40p	6899Z	500p
BD166	30p	BD531	40p	6899A	500p
BD175	30p	BD532	40p	6899B	500p
BD176	30p	BD533	40p	6899C	500p
BD177	30p	BD534	40p	6899D	500p
BD178	30p	BD535	40p	6899E	500p
BD181	32p	BD536	40p	6899F	500p
BD182	32p	BD537	40p	6899G	500p
BD183	32p	BD538	40p	6899H	500p
BD184	32p	BD539	40p	6899I	500p
BD187	32p	BD540	40p	6899J	500p
BD201	33p	BD541	40p	6899K	500p
BD202	33p	BD542	40p	6899L	500p
BD203	42p	BD543	40p	6899M	500p
BD204	42p	BD544	40p	6899N	500p
BD222	31p	BD545	40p	6899O	500p
BD225	31p	BD546	40p	6899P	500p
BD232	31p	BD547	40p	6899Q	500p
BD233	32p	BD548	40p	6899R	500p
BD234	32p	BD549	40p	6899S	500p
BD235	28p	BD550	40p	6899T	500p
BD236	28p	BD551	40p	6899U	500p
BD237	21p	BD552	40p	6899V	500p
BD238	21p	BD553	40p	6899W	500p
BD239	21p	BD554	40p	6899X	500p
BD240	21p	BD555	40p	6899Y	500p
BD241	21p	BD556	40p	6899Z	500p
BD242	21p	BD557	40p	6899A	500p
BD243	21p	BD558	40p	6899B	500p
BD244	21p	BD559	40p	6899C	500p
BD245	21p	BD560	40p	6899D	500p
BD246	21p	BD561	40p	6899E	500p
BD247	21p	BD562	40p	6899F	500p
BD248	21p	BD563	40p	6899G	500p
BD249	21p	BD564	40p	6899H	500p
BD250	21p	BD565	40p	6899I	500p
BD251	21p	BD566	40p	6899J	500p
BD252	21p	BD567	40p	6899K	500p
BD253	21p	BD568	40p	6899L	500p
BD254	21p	BD569	40p	6899M	500p
BD255	21p	BD570	40p	6899N	500p
BD256	21p	BD571	40p	6899O	500p
BD257	21p	BD572	40p	6899P	500p
BD258	21p	BD573	40p	6899Q	500p
BD259	21p	BD574	40p	6899R	500p
BD260	21p	BD575	40p	6899S	500p
BD261	21p	BD576	40p	6899T	500p
BD262	21p	BD577	40p	6899U	500p
BD263	21p	BD578	40p	6899V	500p
BD264	21p	BD579	40p	6899W	500p
BD265	21p	BD580	40p	6899X	500p
BD266	21p	BD581	40p	6899Y	500p
BD267	21p	BD582	40p	6899Z	500p
BD268	21p	BD583	40p	6899A	500p
BD269	21p	BD584	40p	6899B	500p
BD270	21p	BD585	40p	6899C	500p
BD271	21p	BD586	40p	6899D	500p
BD272	21p	BD587	40p	6899E	500p
BD273	21p	BD588	40p	6899F	500p
BD274	21p	BD589	40p	6899G	500p
BD275	21p	BD590	40p	6899H	500p
BD276	21p	BD591	40p	6899I	500p
BD277	21p	BD592	40p	6899J	500p
BD278	21p	BD593	40p	6899K	500p
BD279	21p	BD594	40p	6899L	500p
BD280	21p	BD595	40p	6899M	500p
BD281	21p	BD596	40p	6899N	500p
BD282	21p	BD597	40p	6899O	500p
BD283	21p	BD598	40p	6899P	500p
BD284	21p	BD599	40p	6899Q	500p
BD285	21p	BD600	40p	6899R	500p
BD286	21p	BD601	40p	6899S	500p
BD287	21p	BD602	40p	6899T	500p
BD288	21p	BD603	40p	6899U	500p
BD289	21p	BD604	40p	6899V	500p
BD290	21p	BD605	40p	6899W	500p
BD291	21p	BD606	40p	6899X	500p
BD292	21p	BD607	40p	6899Y	500p
BD293	21p	BD608	40p	6899Z	500p
BD294	21p	BD609	40p	6899A	500p
BD295	21p	BD610	40p	6899B	500p
BD296	21p	BD611	40p	6899C	500p
BD297	21p	BD612	40p	6899D	500p
BD298	21p	BD613	40p	6899E	500p
BD299	21p	BD614	40p	6899F	500p
BD300	21p	BD615	40p	6899G	

DOWN TO EARTH



George Hyllton

SIMPLE VOLTAGE CHANGING

WHILE on holiday we bought a car accessory called a Seven-Output DC/DC converter. It plugged into the cigar lighter socket (i.e. to the 12V car battery). A switch enabled it to be set up for outputs of 1.5V, 3V, 4.5V, 6V, 7.5V, 9V and 12V d.c.

The outputs were taken to a cable terminated in one of those hydra-headed jacks capable of being plugged into almost any d.c. power socket on a radio, tape recorder, etc.. The stated output was 500mA max. Handy; but how did it work?

PERFORMANCE

The circuit diagram is given in Fig. 1 (omitting a l.e.d. and a polarity-reversal switch, irrelevant here). The performance, when powered by a 12.2V d.c. supply is given in Fig. 2.

The mode of operation is simple enough. The chain of resistors R1 to R7 forms a voltage divider (see Fig. 1). The voltage-selecting switch S1 picks off one of the preset voltages and applies it to the base of TR1 (a small silicon power transistor, type unknown).

The transistor is connected as an emitter-follower and passes on a voltage to the output. With an ideal "follower" this would be the same as the selected input. In practice it is lower by about 0.7V, the base-emitter voltage (V_{BE}) of TR1.

Because of this base-emitter drop it is necessary to apply voltages to the base about 0.7V higher than the nominal output voltages. If the input voltage were exactly 12V, if the resistances were exactly as shown, and if the transistor drew no base current then the divider voltages would have the values shown in brackets.

These are all above the nominal outputs but not by equal amounts. However, it must be remembered that the actual terminal voltage of a charged 12V car battery is a variable quality. For a fully charged car battery it is typically 12.6V but may rise to 14V or even more when the battery is on charge.

On the other hand, in cars with sealed batteries, where it would be dangerous to reach high voltages, automatic controls may restrict the voltages to somewhere close to the nominal 12V. And, should the battery get exceptionally run down, the voltage may be less than 12V.

Clearly, the designer must compromise by choosing a plausible battery voltage to give the best compromise on voltage accuracy. To get an output of 1.5V it is necessary to apply about 2.2V to TR1, which is why resistor R7 is higher than the other resistances. From 1.5V, the outputs rise in steps of 1.5V so the flow through the divider chain ought to provide increments of 1.5V.

BASE CURRENT LOADING

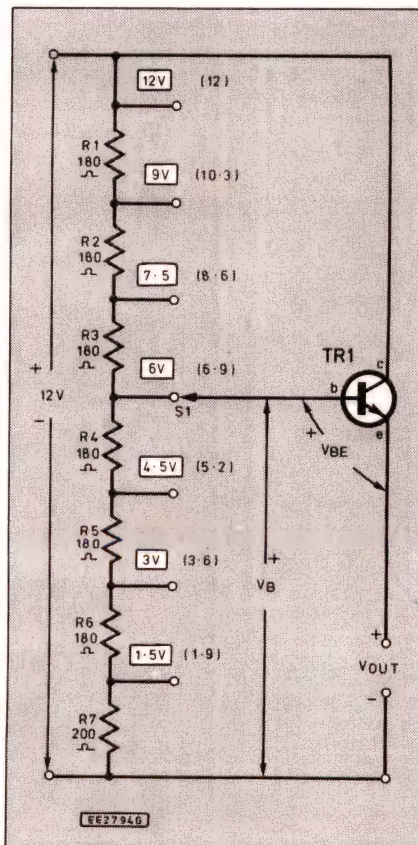
From the measured performance with the 12.2V input I used, the output voltages up to 9V are close to their nominal values when the output current is 400mA. The 12V output setting is less, but on this range the circuit doesn't really work, because the base and collector are connected together and the transistor behaves as a diode.

The designer has to allow for the effect of base current. This increases the voltage drop in all resistors above the tap point, and so pulls the output down a little.

How much? The base current depends on the current gain of the transistor. To make the circuit operate consistently the current gain should be precisely known. In practice, of course, it is variable.

A good compromise is to bleed as much current as is reasonable through the divider and to use a high gain transistor. This way the effect of base current is minimised and, provided the divider passes several times the maximum base current the effect of variations is small.

Fig. 1. Car Voltage Converter circuit diagram.



VOLTAGE VARIATIONS

The performance curves (Fig. 2) show, however, that variations are not negligible. On the 6V range, for example, the output is about 7V at low loads, falling to about 5.7V at maximum load. These voltages must suffer further variations as the car battery charges up or runs down.

With the car battery at 14V the voltage settings will all go about 15 per cent higher. At 11V, all go about 10 per cent lower. Thus, there seems to be some risk that equipment powered by such a converter may sometimes receive uncomfortably high voltages, and sometimes voltages too low for corrected operation.

It all depends on how tolerant the equipment is. Fortunately, much battery powered equipment is quite tolerant.

Can we do better? Of course we can, if extra complexity and expense are permissible. Instead of a simple emitter follower a proper variable voltage stabiliser could be used. But can we do better at minimal extra cost and complexity?

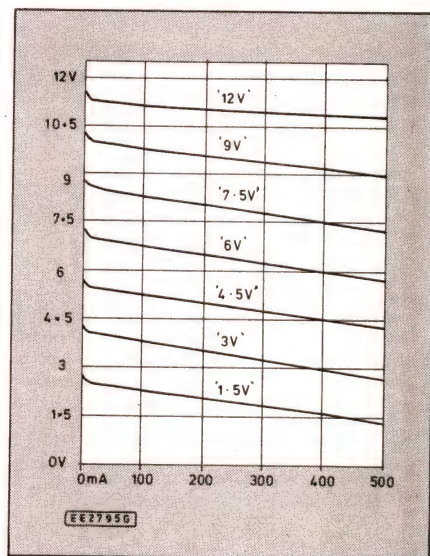


Fig. 2. Car converter circuit outputs.

DARLINGTON OUTPUT

The effect of base current variations can be made negligible by using a compound emitter follower such as the Darlington stage (TR1, TR2) in Fig. 3. Here the effective current gain is the product of the gains of TR1 and TR2. This can easily be several thousand.

The base current of TR1 is very small and imposes little loading on the divider chain. However, it is still necessary for a few milliamps to flow through the divider. Some economy in standby drain can be obtained by using this current to light an indicator l.e.d. D1. A red l.e.d. runs at about 1.6V and the addition of a resistor can bring this up to a suitable voltage to drive the 1.5V output.

Since there are two V_{BE} drops between input and output of the Darlington "pair" the output is about 1.4V less than the input, which must be about 2.9V for 1.5V output. Each resistance above the "1.5V" tap must add 1.5V, until the "9V" tap, which requires 10.4V. Resistor R1 must drop 1.6V if the input is exactly 12V. (The "12V" output has been abandoned in Fig. 3).

Although the effect of base current loading is eliminated, the output voltage

of the Darlington circuit still drops as the current drawn is increased. For my test circuit the outputs at 500mA were down by about 0.5V on the low-load value.

The reason is that V_{BE} varies with the base current. If the Darlington has a current gain of 1000 then TR1's current must be 0.5mA at maximum output current, falling to virtually zero for small currents. Transistor TR2's base current varies from nearly zero at low output current to perhaps 10mA-20mA at maximum.

These are wide variations and the V_{BE} drops are bound to change. The effect is quite serious at low output voltages, where a 0.5V change is large in percentage terms.

The effect can be reduced by connecting resistances R8 and R9 (shown dotted). These allow small collector currents to flow even when there is no load, so the base currents don't change from zero to maximum but from a certain amount to maximum.

TRIPLE FOLLOWER

The situation can be improved by using a triple follower (Fig 4). This has very high current gain, so the input base current is very low. Also there is only one base-emitter drop (TR1's - about 0.6V at the low base current drawn) between base input and output.

With my 12.2V supply the output voltages were all close to the required values, after resistor R7 was trimmed by resistor R8 to set the 1.5V output. The voltages for 1.5V to 9V output fell by about 0.25V at about 400mA output.

The 12V output is not really subject to follower action and is included merely for convenience; resistor R9 limits base current to prevent the destruction of TR1 in the event of an output short. (The omission of a corresponding resistance in Fig. 1 looks like a designer error.)

The circuit can be adapted to voltages above or a little below 12V by adjusting resistor R1 to obtain a correct output on the 9V setting. The other resistances are then the same, with the proviso that resistor R7 may need trimming to obtain a correct 1.5V (One could use a 2.2 kilohm preset potentiometer in place of resistors R7 and R8).

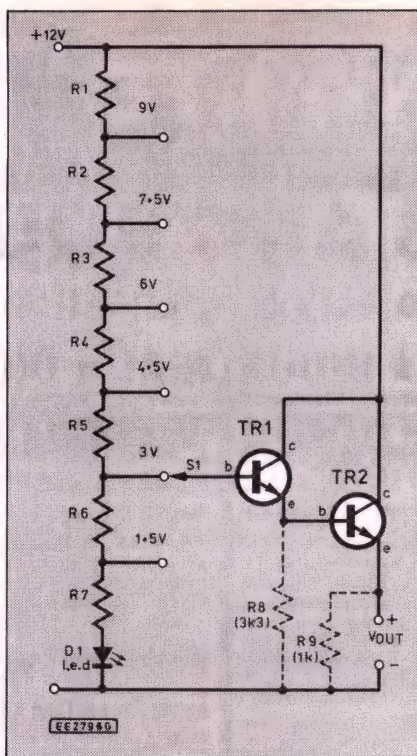


Fig. 3. Using a Darlington transistor output stage.

DISSIPATION

The problems of "energy" or "heat" dissipation in the circuit of Fig. 4 is greatest at low output voltages because the transistors then have to absorb most of the battery voltage. Assuming 12.6V input and 1.5V output there is 11V across TR3. At 500mA output it must dissipate nearly 5.5W and a heatsink is essential.

Under shorted-output conditions the dissipation can be very high and the best policy is to choose a transistor for TR3 capable of handling currents much higher than needed and to include a fuse as shown. There is then a reasonable chance that a fuse will blow before the transistors.

The dissipation in transistor TR2 is not negligible and a small power type should

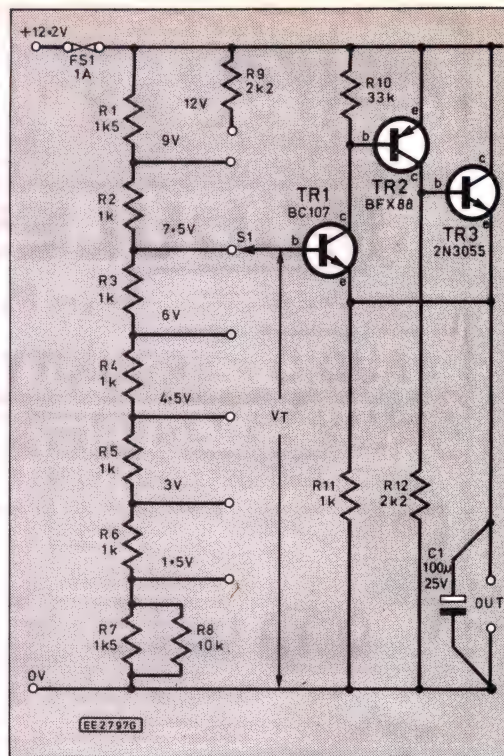


Fig. 4. Triple Follower. Only TR1's base-emitter drop comes between the tap voltage V_T and the output. Capacitor C1 is included to reduce the risk of instability.

be used. Dissipation in TR1 is low except under fault conditions.

You may well feel that, in view of the complexity of a triple follower, it would be cheaper and better to buy a variable i.c. stabiliser. These are now relatively cheap and can provide short-circuit protection and stabilisation against input voltage variations.

All a follower can do is provide constant voltage when the load varies, which stabilisers do too. If you have suitable transistors in the spares box, however, it might be attractive.

Triple followers are used in the output stages of some audio amplifiers. The advantage there is that they make little current demands on the driver stage.

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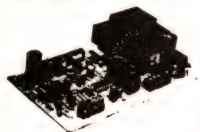
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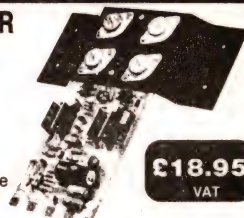
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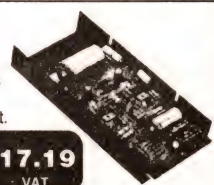
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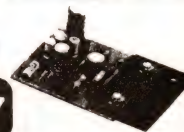
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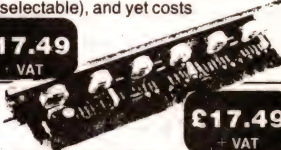


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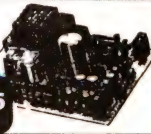
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INTERFACE

Robert Penfold



INTERFACE is a new series which, as explained more fully in last month's issue of *Everyday Electronics*, will cover interfacing to any microcomputer that is currently quite popular. Other technical topics may also be covered, such as programs that are of particular interest to *Everyday Electronics* readers. Here we are talking about programs such as printed circuit design, circuit simulation, etc., not the latest in "zap" everything in sight games!

Expansion

I think it is fair to say that most of the modern microcomputers have less scope for home-made add-ons than do most of the computers from a few years ago. With computers such as the VIC-20, Commodore 64, and BBC model B there are user ports which can very easily be used to control motors, i.e.d.s, etc., or to read digital signals.

There is nothing similar on most of the computers currently on offer. In some cases there is a printer port that can be used in a similar way to a user port, but in most systems this port will be occupied by the printer.

Another problem is that most modern computers do not have anything that is strictly comparable to the expansion ports of the popular 8 bit computers. The expansion ports of the ZX81, Spectrum, BBC computers, etc. have their peculiarities, but still offer a fairly simple route to massive expansion. In fact the maximum possible expansion is so great with these computers that there is little likelihood of ever occupying more than a few percent of the available addresses. Producing DIY add-ons for these ports is reasonably straightforward.

Expansion ports on more recent computers tend to be large, inaccessible, and relatively difficult to use. In some cases there seems to be no proper expansion port at all. It is probably possible to add your own peripheral devices to any current computer, but in some cases this task will be less than straightforward. In some cases the degree of expansion possible may be rather limited by the standards of the past.

Slot Machines

I should imagine that the IBM PCs and the various "compatibles" from Amstrad etc. are the most popular computers so far produced. The success of these computers is largely based on their widespread acceptance in the business world. I produce the text and drawings for *Everyday Electronics* articles on a PC AT compatible, and on reaching the EE offices they are processed using more IBM compatibles. Although the "PCs" (as IBMs and compatibles are

popularly known) are the standard business computers, in recent years they have also sold well as home computers.

In some respects they are perhaps something less than ideal for home use. The graphics capabilities of the early models were either limited or non-existent, but with the much improved EGA and VGA graphics boards now being commonplace, the displays of most modern PCs are really excellent. The same is not true of the sound generator, which remains rather weak even by 8 bit computer standards. The PCs are quite powerful computers, and are backed-up by masses of software of just about every conceivable type. These days, this includes much software of interest to home users.

PC Add Ons

For the add-on enthusiast the PCs offer excellent potential. All PCs and true compatibles have about eight expansion slots within the main system unit. Unlike most other microcomputers, expansion boards fit within the computer, rather than externally on the rear of the unit. If the board must connect to the outside world, this is achieved via connectors mounted on the rear of the board which can be accessed via cutouts in the rear of the computer's case.

The number of expansion slots varies somewhat from one type and make of PC to another, but any modern PC that is a true compatible should have around six to eight slots. Some of these are occupied by essential pieces of hardware, such as the display adaptor, disk controller, and serial/parallel ports. Typically there would still be something like three or four spare expansion slots, leaving plenty of scope for specialised add-ons.

The easy approach to interfacing to a PC is to fit it with a few specialised interface cards, such as analogue to digital and digital to analogue converter boards, and parallel interface boards. Temperature sensors, relay drivers, etc. are then easily connected up to these boards and used with the computer. This method has definite attractions, but suitable interface boards are relatively difficult to obtain, and can be quite expensive.

It is much cheaper to build your own interface boards, including on the board some or all of the additional circuitry for your particular applications if desired. Interfacing to a PC, from the electronics point of view, is more simple than you might expect. Quite simple address and control line decoding will usually suffice, and in this respect interfacing to the PCs is more straightforward than interfacing to the buses of many eight bit computers.

There is an awkward aspect to PC inter-

facing in that a double-sided printed circuit board is needed to fit into the expansion slot, and it must be made quite accurately if everything is to fit into place and operate properly.

With eight bit computers it is quite common to have add-ons connected to the computer via a suitable connector and a length of ribbon cable. Due to the higher clock speeds involved with PCs, and the minimal latitude in the timing of most signals, this method is not a very practical one. It can be used, but only if the ribbon cable is kept very short indeed. This is a feasible method for testing prototype circuits, but is not a very practical one for the final units.

8 Bit Bus

There are several types of PC expansion bus. The latest IBM machines and a few compatibles use the MCA (micro channel architecture) type, which is a very modern high speed bus. A few compatibles use the EISA (Extended Industry Standard Architecture) type, which is a form of 32 bit bus. This is based on what I suppose would have to be considered the standard PC bus, which is the ISA (Industry Standard Architecture) type. It is actually the 16 bit version of the ISA bus, with some extra connections to take the extra data lines etc.

The original PC bus is an eight bit type, and it is the one still used on the 8088 and 8086 based PCs (the XT type). The ATs and compatibles (including most 80386 based PCs) have a 16 bit bus, but this is the original 8 bit variety with an extra connector to carry the eight extra data lines plus some extra control lines. This method means that there is good compatibility between the XT and AT machines, with most 8 bit cards operating perfectly well in either type of computer.

Of course, a 16 bit card cannot operate properly in a machine that only has 8 bit expansion slots, although some 16 bit cards can be switched to 8 bit operation or will automatically switch to this mode if necessary.

As far as most user add-ons are concerned, they only need the basic 8 bit bus. Unless you have some form of AT compatible, you are obviously restricted to 8 bit expansion cards anyway. For the time being we will only consider the basic 8 bit bus. Fig.1 shows the normal method of pin numbering for the 8 bit expansion slot, which is a 2 x 31 way 0.1 inch pitch edge connector. This is a list of all the lines present on an 8 bit expansion slot:-

Many of these lines are familiar microprocessor types.

The eight data lines (D0 to D7) and the

Terminal No.	Function	Terminal No.	Function
A1	I/O CH CK	B14	-IOR
A2	D7	B15	-DACK3
A3	D6	B16	DRQ3
A4	D5	B17	-DACK1
A5	D4	B18	DRQ1
A6	D3	B19	-DACK0
A7	D2	B20	CLK
A8	D1	B21	IRQ7
A9	D0	B22	IRQ6
A10	I/O CH RDY	B23	IRQ5
A11	AEN	B24	IRQ4
A12	A19	B25	IRQ3
A13	A18	B26	-DACK2
A14	A17	B27	TC
A15	A16	B28	ALE
A16	A15	B29	+5V
A17	A14	B30	OSC
A18	A13	B31	GND
A19	A12		
A20	A11		
A21	A10		
A22	A9		
A23	A8		
A24	A7		
A25	A6		
A26	A5		
A27	A4		
A28	A3		
A29	A2		
A30	A1		
A31	A0		
B1	GND		
B2	RESET		
B3	+5V		
B4	IRQ2		
B5	-5V		
B6	DRQ2		
B7	-12V		
B8	Reserved		
B9	+12V		
B10	GND		
B11	-MEMW		
B12	-MEMR		
B13	-IOW		

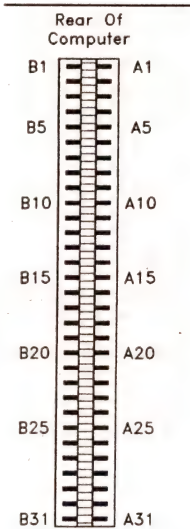


Fig. 1. The numbering used for the IBM 8-bit bus. The connector is a 2 x 31-way 0.1 inch pitch edge type.

twenty address lines (A0 to A19) should require no further explanation. Neither should the ground and various supply rail connections. One point worth making is that not all the address lines are used for input/output devices. Normally the lower 16 address lines are used, giving a massive 64K address space. In the PCs only the ten least significant address lines are used though, giving the reduced (but still substantial) address space of 1K.

Read/Write

The 8088 series of microprocessors have the same origins as the Z80, and some of the control lines are similar to Z80 types. In particular, the 8088 series have separate input/output and memory maps, with two sets of read/write lines for the two types of access.

The read/write lines for memory accesses are -MEMR and -MEMW, while -IOR and -IOW perform the same functions when input/output devices are accessed. These are all negative active lines (as denoted by the "-" signs). User add-ons would normally go into the input/output map. Therefore, -IOR and -IOW are important lines which will normally need to be decoded by user add-ons.

AEN (address enable) is another important line for user add-ons. This indicates whether DMA (direct memory access) or processor bus cycles are taking place. Add-ons should only be activated during processor cycles, when AEN is low.

The lines mentioned so far are the only ones that are essential to most PC interfacing, but we will briefly consider the other lines. ALE is a timing output which can be used as an aid to synchronising events to processor bus cycles.

Inputs DRQ1 to DRQ4, outputs -DACK0 to -DACK3, and TC (the terminal count output) are concerned with direct memory access. IRQ0 to IRQ7 are active high interrupt request lines, but note that IRQ0 and IRQ1 are not available on the expansion bus. These are used by the system for the time of day clock and the keyboard. Some of the interrupt lines that are accessible are likely to be used by standard expansion cards such as the serial and parallel ports, mouse interface card, etc.

Clock

Two clock signals are available on the bus. These are CLK and OSC. The former is the system clock, which has a 2 to 1 duty cycle and is at 4.77MHz on the original PCs and some compatibles. On ATs and XTs used in the "turbo" mode this clock will be at a higher frequency. The OSC signal is a 14.318MHz signal which is apparently intended mainly for use with the CGA graphics card.

RESET is an output which is active low, and which provides a pulse at switch-on that can be used to reset circuits on expansion cards. I/O CH RDY is an input which is normally high, but which can be taken low by a slow peripheral circuit in order to insert additional wait states. Most user add-ons are fast enough to avoid the need for inserted wait states.

I/O CH CK is a normally high input which can be pulled low if a parity error is detected (and a non-maskable interrupt is then generated). This can be used with input/output or memory circuits, but is mainly used with the latter.

Next month we will consider suitable spots for user add-ons in the input/output map, and address decoder circuits.

SHOP TALK

with David Barrington

12V Lamp/Vacuum Cleaner Charger

We cannot foresee any purchasing difficulties for the components required to build the 12V Lamp/Vacuum Cleaner Charger.

Some readers may experience problems locating a local source for the 4-pole 3-position slide switch. As only two poles are used, it may prove easier to buy and use two, two-position slide switches as indicated in the article.

Versatile Bench Power Supply

Most of the components required for the Versatile Bench Power Supply, the first of the Teach-In '91 back-up projects for the Design Your Own Circuit series should be available generally. We understand that some of our advertisers are making up kits for this series and a look through the advertisement pages should produce a local source.

8-Channel Microcontroller Light Sequencer

The MLS1A programmed i.c. used in

the 8-Channel Microcontroller Light Sequencer is a special item and only available from Magenta Electronics. The chip, pre-programmed and ready to run, costs £14.95 plus post and packing.

A full kit of parts (less only the battery and solder) including the printed circuit boards, programmed i.c., heatsink block, punched and labelled case is available from Magenta for the sum of £55.95 including VAT plus £2 postage and packing. All parts are available separately.

For case drilling templates and i.c. programmed light sequences send a large stamped addressed envelope to Magenta Electronics, Dept EE, 135 Hunter Street, Burton on Trent, Staffs, DE14 2ST. ☎ 0283 65435.

The two printed circuit boards for this project are obtainable from the EE PCB Service, codes EE708 and EE709.

Colour Changing Christmas Lights

The bi-colour i.e.d.s used in the Colour Changing Christmas Lights project now seem to be recognised as

standard stock lines by most component advertisers and should not cause any sourcing problems. The rest of the components should also be readily available.

The small printed circuit board for this project is available from the EE PCB Service, code EE707.

As there is mains voltage on the p.c.b. and, due to the nature of this project which likely to attract the attention of the younger members of the family, extreme care should be taken when working on this unit.

It would certainly be advisable to use nylon nut and bolts to secure the board and "display lights" sockets in the case. You could also consider sealing the case lid, covering the fixing screws, with insulating tape.

Electronic Dipstick

We do not expect any component buying problems to be encountered by constructors of the Electronic Dipstick, this month's Pocket Money Project. Most of our advertisers stock the 10-way i.e.d. display. You could, if you wish, use the individual stackable types if the single package type is hard to come by.

The rest of the components are standard "off-the-shelf" items. It might prove cheaper to buy a single large piece of stripboard and cut this to size for the two small boards.

DIRECT BOOK SERVICE

The books listed have been selected as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full details are given on the last book page.

For another selection of books see next month's issue.

MORE BOOKS NEXT MONTH — MORE BOOKS NEXT MONTH

PROJECT CONSTRUCTION

HOW TO GET YOUR ELECTRONIC PROJECTS WORKING

R. A. Penfold

We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

96 pages Order code BP110 £2.50

HOW TO DESIGN AND MAKE YOUR OWN P.C.B.s

R. A. Penfold

Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

80 pages Order code BP121 £2.50

BEGINNER'S GUIDE TO BUILDING ELECTRONIC PROJECTS

R. A. Penfold

Shows the complete beginner how to tackle the practical side of electronics, so that he or she can confidently build the electronic projects that are regularly featured in magazines and books. Also includes examples in the form of simple projects.

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O. Bishop

These projects range in complexity from a simple colour temperature meter to an infra-red laser. There are novelties such as an electronic clock regulated by a resonating spring, and an oscilloscope with solid-state display. There are scientific measuring instruments such as a pH meter and an electro-cardiometer. All projects have a strong scientific flavour. The way they work, and how to build and use them are fully explained.

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PRACTICAL ELECTRONIC BUILDING BLOCKS—BOOK 1 PRACTICAL ELECTRONIC BUILDING BLOCKS—BOOK 2

R. A. Penfold

These books are designed to aid electronic enthusiasts who like to experiment with circuits and produce their own projects, rather than simply following published project designs.

BOOK 1 contains: Oscillators—sinewave, triangular, squarewave, sawtooth, and pulse waveform generators operating at audio frequencies. Timers—simple monostable circuits using i.c.s, the 555 and 7555 devices, etc. Miscellaneous—noise generators, rectifiers, comparators and triggers, etc.

BOOK 2 contains: Amplifiers—low level discrete and op-amp circuits; voltage and buffer amplifiers including d.c. types. Also low-noise audio and voltage controlled amplifiers. Filters—high-pass, low-pass, 6, 12, and 24dB per octave types. Miscellaneous—i.c. power amplifiers, mixers, voltage and current regulators, etc.

BOOK 1 128 pages Order code BP117 £1.95
BOOK 2 112 pages Order code BP118 £1.95

ELECTRONIC ALARM CIRCUITS MANUAL

R. M. Marston

One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.

Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur.

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DESIGNING DC POWER SUPPLIES

G. C. Loveday C.Eng MIERE

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131 pages Order code BM2 £6.95

ELECTRONIC POWER SUPPLY HANDBOOK

Ian R. Sinclair

This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, IC switch-mode regulators, DC-DC converters and inverters.

The devices, their operating principles and typical circuits are all dealt with in detail. The action of rectifiers and the reservoir capacitor is emphasised, and the subject of stabilisation is covered. The book includes some useful formulae for assessing the likely hum level of a conventional rectifier reservoir supply.

136 pages Order code PC108 £7.95

MODERN OPTO DEVICE PROJECTS

R. A. Penfold

In recent years, the range of opto devices available to the home constructor has expanded and changed radically. These devices now represent one of the more interesting areas of modern electronics for the hobbyist to experiment in, and many of these devices have useful practical applications as well. This book provides a number of practical designs which utilize a range of modern opto-electric devices, including such things as fibre optics, ultra bright l.e.d.s and passive IR detectors etc.

While many of these designs are not in the "dead simple" category, they should be within the capabilities of anyone with a reasonable amount of experience in electronics construction and some of the more simple designs are suitable for beginners.

104 pages Order code BP194 £2.95

DIGITAL LOGIC GATES AND FLIP-FLOPS

Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning. This is not a constructor's book in the sense of presenting circuits to build and use, it is for the user who wants to design and troubleshoot digital circuitry with considerably more understanding of principles.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

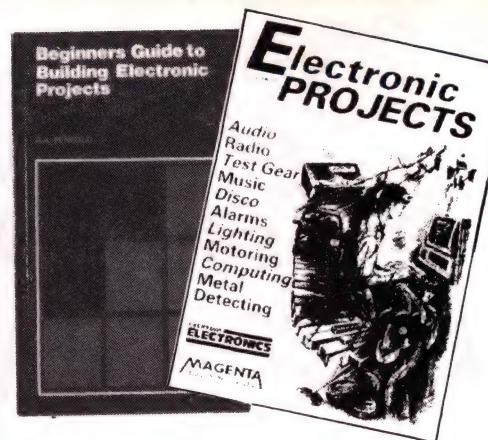
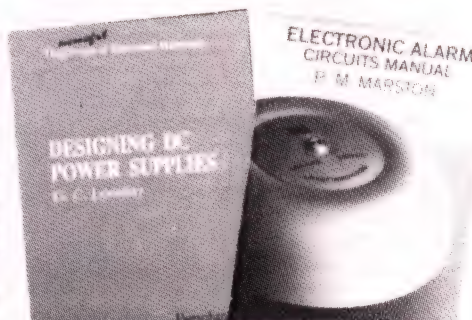
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E. A. Parr

This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

160 pages Order code BP88 £2.95



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128 pages (A4 size) Order code EP1 £2.45

MICRO INTERFACING CIRCUITS—BOOK 1 MICRO INTERFACING CIRCUITS—BOOK 2

R. A. Penfold

Both books include practical circuits together with details of the circuit operation and useful background information. Any special constructional points are covered but p.c.b. layouts and other detailed constructional information are not included.

Book 1 is mainly concerned with getting signals in and out of the computer. Book 2 deals primarily with circuits for practical applications.

Book 1 112 pages Order code BP130 £2.25
Book 2 112 pages Order code BP131 £2.75

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Keith Brindley

There are a considerable number of transducers. Look through any electronic components catalogue and you'll find a wide variety of types, and each type has many versions. It's not easy to choose a transducer correctly for a particular function. In many specifications, terms and procedures are referred to which might deter you from using one that is, in fact, the best for the job. Yet, opting to use a transducer merely because it is easier to interface into the measuring system is not the answer. A greater knowledge of all types of transducers capable of doing the task is the ideal, and only then can a totally satisfactory decision be made to use one in particular.

176 pages Order code NE17 £12.95

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS

Robert Penfold

Robots and robotics offer one of the most interesting areas for the electronics hobbyist to experiment in. Today the mechanical side of robots is not too difficult, as there are robotics kits and a wide range of mechanical components available. The micro controller is not too much of a problem either, since the software need not be terribly complex and many inexpensive home computers are well suited to the task.

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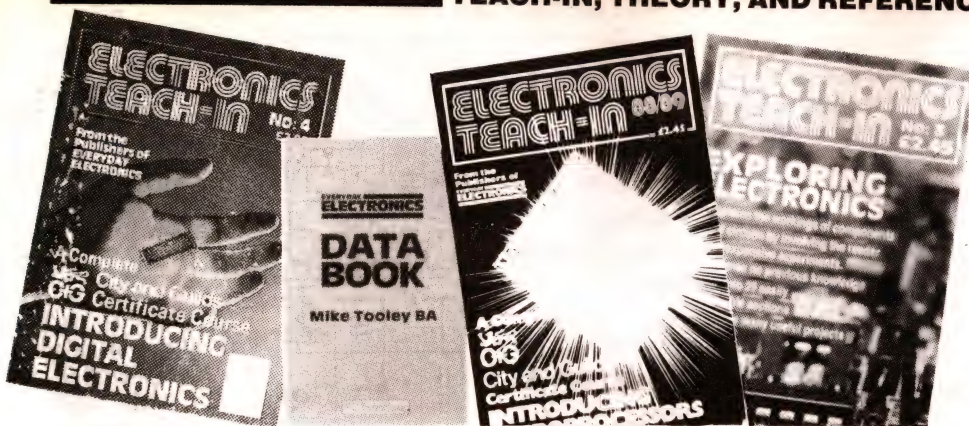
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Michael J. Cockcroft

Although this book is primarily a City & Guilds Introductory level course (726/301), approximately 80% of the information forms a very basic introduction to electronics in general, it therefore provides an excellent introductory text for beginners and a course and reference book for GCSE students.

Full details on registering for C&G assessment, details of assessment centres, components required and information on the course in general are given.

The City & Guilds introduction to module 726/301 reads: "A candidate who satisfactorily completes this module will have a competence to identify basic components and digital integrated circuits and connect them together to form simple working circuits and logic units." This provides an excellent introduction to the book
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**ELECTRONICS TEACH-IN 88/89—
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Mike Tooley BA (published by *Everyday Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc.
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Then help is at hand with this inexpensive book, in as simple a way as possible and without too much complex mathematics and formulae.

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Owen Bishop

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E. A. Parr

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E. A. Parr

An excellent grounding in microprocessors, this book is broadly relevant to the whole of our Introductory Microprocessors course. It is easy to read and well illustrated.
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(published by EE in association with PC Publishing)

This book is an invaluable source of information of everyday relevance in the world of electronics. It contains not only sections which deal with the essential theory of electronic circuits, but it also deals with a wide range of practical electronic applications.

It is ideal for the hobbyist, student, technician and engineer. The information is presented in the form of a basic electronic recipe book with numerous examples showing how theory can be put into practice using a range of commonly available "industry standard" components and devices.

A must for everyone involved in electronics!
256 pages Order code DATA £8.95

ELECTRONIC HOBBYISTS HANDBOOK

R. A. Penfold

Provides an inexpensive single source of easily located information that the amateur electronics enthusiast is likely to need for the day-to-day pursuance of this fascinating hobby. Covers common component colour codes. Details the characteristics and pinouts of many popular semiconductor devices, including various types of logic ICs, operational amplifiers, transistors, FETs, unijunctions, diodes, rectifiers, SCRs, diacs, triacs, regulators and SMDs, etc. Illustrates many useful types of circuits, such as timers and oscillators, audio amplifiers and filters, as well as including a separate section on power supplies. Also contains a multitude of other useful data.
88 pages Order code BP233 £4.95

**ESSENTIAL THEORY FOR THE
ELECTRONICS HOBBYIST**

G. T. Rubaroe, T. Eng (C.E.I.), Assoc. I.E.R.E.

The object of this book is to supply the hobbyist with a background knowledge tailored to meet his or her specific requirements and the author has brought together the relevant material and presented it in a readable manner with minimum recourse to mathematics.
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PRACTICAL DIGITAL ELECTRONICS HANDBOOK
Mike Tooley (Published in association with *Everyday Electronics*)

The vast majority of modern electronic systems rely heavily on the application of digital electronics, and the *Practical Digital Electronics Handbook* aims to provide readers with a practically based introduction to this subject. The book will prove invaluable to anyone involved with the design, manufacture or servicing of digital circuitry, as well as to those wishing to update their knowledge of modern digital devices and techniques. Contents: Introduction to integrated circuits; basic logic gates; monostable and bistable devices; timers; microprocessors; memories; input and output devices; interfaces; microprocessor buses. Appendix 1: Data. Appendix 2: Digital test gear projects; tools and test equipment; regulated bench power supply; logic probe; logic pulser; versatile pulse generator; digital IC tester; current tracer; audio logic tracer; RS-232C breakout box; versatile digital counter/frequency meter. Appendix 3: The oscilloscope. Appendix 4: Suggested reading. Appendix 5: Further study.
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E. A. Parr, B.Sc., C.Eng., M.I.E.E.

This book is intended for people who wish to progress beyond the stage of BASIC programming to topics such as machine code and assembly language programming, or need hardware details of a Z80 based computer.
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R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone. Computer-based music systems in the past have tended to be either horrendously expensive, very crude, or both! These days, prices are much more modest and the potential of the equipment is much greater. Consequently a lot of musicians are being tempted into the unfamiliar territory of computer music systems.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.
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A CONCISE INTRODUCTION TO MS-DOS

N. Kantaris

This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.

The guide covers versions 3.0, 3.1 and 3.2 of both PC-DOS and MS-DOS as implemented by IBM and other manufacturers of "compatible" microcomputers, including the AMSTRAD PCs. It covers both floppy disc-based systems and hard disc-based systems.
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**AN INTRODUCTION TO 68000 ASSEMBLY
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R. A. & J. W. Penfold

Obtain a vast increase in running speed by writing programs for 68000 based micros such as the Commodore Amiga, Atari ST range or Apple Macintosh range etc., in assembly language. It is not as difficult as one might think and this book covers the fundamentals.
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**THE ART OF PROGRAMMING THE ZX
SPECTRUM**

M. James, B.Sc., M.B.C.S.

It is one thing to have learnt how to use all the Spectrum's commands and functions, but a very different one to be able to combine them into programs that do exactly what you want them to. This is just what this book is all about—teaching you the art of effective programming with your Spectrum.
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Ian Sinclair

The *Beginner's Guide to Hi-Fi* will appeal to the audio enthusiast, whether newly won over by advances in technology or well established and wondering whether to update equipment. The book deals with the sound from its sources in the studio to its ultimate end in your ears, and shows what sound is, how it is recorded and how it is reproduced.

Every aspect of Hi-Fi, from pickup cartridges to loudspeakers, has been covered, and the emphasis has been on explaining design aims. Cassette systems have been given considerable prominence, including the more modern Dolby C and dbx noise reduction systems. The CD record has been covered in detail so that you can find out just why this system of sound reproduction is so superior.

194 pages

Temporarily out of print.

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K. H. Recorr

Shows the reader how, with just a test-meter, to go about recording the particular signature of an unmarked i.c. which should enable the i.c. to then be identified with reference to manufacturers' or other data. An i.c. signature is a specially plotted chart produced by measuring the resistances between all terminal pairs of an i.c.

Chart Order code BP101 £0.95

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A. Michaels

Designed to help the user in finding possible substitutes for a large selection of the many different types of diodes that are available. Besides simple rectifier diodes, also included are Zener diodes, i.e.d.s, diacs, triacs, thyristors, OCIs, photo and display diodes.

144 pages

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A. Michaels

Shows equivalents and pin connections of a popular selection of European, American and Japanese linear i.c.s. Also includes details of functions, manufacturer and country of origin.

320 pages

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RADIO AND ELECTRONIC COLOUR CODES AND DATA CHART

B. B. Babani

Although this chart was first published in 1971 it provides basic information on many colour codes in use throughout the world, for most radio and electronic components. Includes resistors, capacitors, transformers, field coils, fuses, battery leads, speakers, etc. It is particularly useful for finding the values of old components.

Chart

Order code BP7 £0.95

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AN INTRODUCTION TO AMATEUR RADIO

I.D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.

This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages

Order code BP257 £3.50

INTERNATIONAL RADIO STATIONS GUIDE

P. Shore

Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed to guide him or her around the ever more complex radio bands. This new edition has been completely revised and rewritten and incorporates much more information which is divided into the following sections:

Listening to Short Wave Radio; ITU Country Codes; World-wide Short Wave Radio Stations; European, Middle East and North African Long Wave Radio Stations; European, Near East and North African Medium Wave Radio Stations; Canadian Medium Wave Radio Stations; USA Medium Wave Radio Stations; Broadcasts in English; Programmes for DXers and Short Wave Listeners; UK FM Radio Stations; Time differences from GMT; Abbreviations; Wavelength/Frequency Conversion.

320 pages

Order code BP255 £4.95

AERIAL PROJECTS

R. A. Penfold

The subject of aerials is vast but in this book the author has considered practical aerial designs, including active, loop and ferrite aerials which give good performances and are relatively simple and inexpensive to build. The complex theory and mathematics of aerial design have been avoided.

Also included are constructional details of a number of aerial accessories including a pre-selector, attenuator, filters and tuning unit.

96 pages

Order code BP105 £2.50

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN

V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages

Order Code BP256

£2.95

MUSICAL APPLICATIONS OF THE ATARI ST's

R. A. Penfold

The Atari ST's are now firmly established as *the* computers to use for electronic music applications. The range and sophistication of these applications are much greater than most people may realise, but there are still a lot of misconceptions about just what can and cannot be achieved. This book will help you sort out the fact from the fallacy and to get the most musically from the ST's.

A wide selection of topics are covered, including the internal sound chip; MIDI; applications programs such as sequencing and score writing, etc; simple but useful add-on projects and MIDI programming.

90 pages

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TRANSISTOR RADIO FAULT-FINDING CHART

C. E. Miller

Used properly, should enable the reader to trace most common faults reasonably quickly. Across the top of the chart will be found four rectangles containing brief description of these faults, viz—sound weak but undistorted, set dead, sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

Chart

Order code BP70

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HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT

R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits. Plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsters, and crystal calibrators.

104 pages

Order code BP267

£3.50

AN INTRODUCTION TO SATELLITE TELEVISION

F.A. Wilson

As a definitive introduction to the subject this book is presented on two levels. For the absolute beginner or anyone thinking about purchasing or hiring a satellite TV system, the story is told as simply as such a complex one can be in the main text.

For the professional engineer, electronics enthusiast, student or others with technical backgrounds, there are numerous appendices backing up the main text with additional technical and scientific detail formulae, calculations, tables etc.

There is also plenty for the DIY enthusiast with practical advice on choosing and installing the most problematic part of the system—the dish antenna.

104 pages

Order Code BP195

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F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

A look at the electronic fundamentals over the whole of the communication scene. This book aims to teach the important elements of each branch of the subject in a style as interesting and practical as possible. While not getting involved in the more complicated theory and mathematics, most of the modern transmission system techniques are examined including line, microwave, submarine, satellite and digital multiplex systems, radio and telegraphy. To assist in understanding these more thoroughly, chapters on signal processing, the electromagnetic wave, networks and transmissions assessment are included, finally a short chapter on optical transmission.

256 pages

Order Code BP89

£2.95

AN INTRODUCTION TO VHF/UHF FOR RADIO AMATEURS

I. D. Poole

This book covers the essentials required to gain the most from using the VHF and UHF bands. As such it will be of use to both the newcomer and more experienced operator alike.

Topics included in this book include propagation, descriptions of the bands with outlines of the bandplans and channels, aerials, receivers, transmitters and a special chapter on scanners. In addition to this repeater and mobile operation are included as well as DXing and data modes together with a section on packet radio.

102 pages

Order Code BP281

£3.50

PRACTICAL MIDI HANDBOOK

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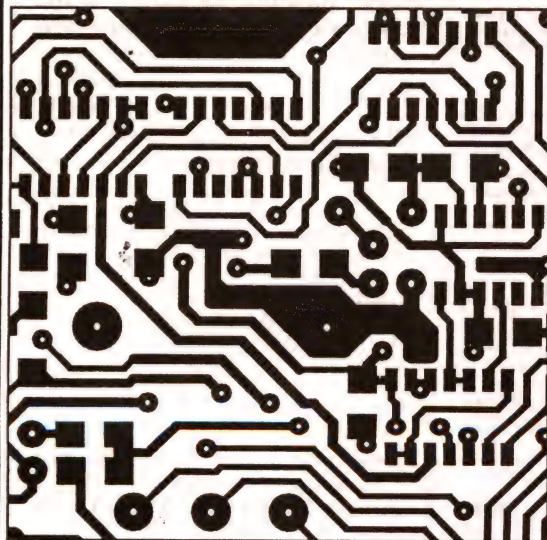
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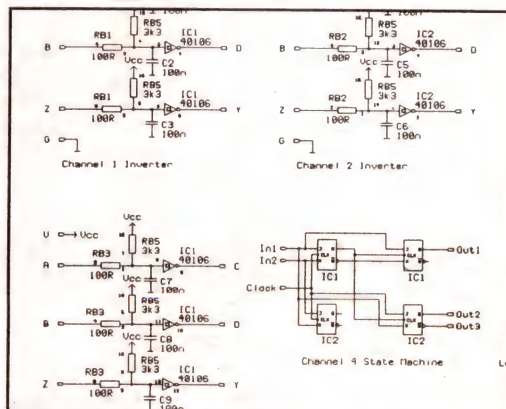
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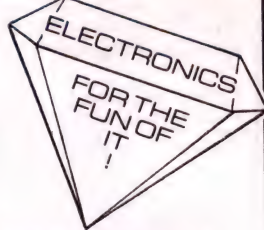
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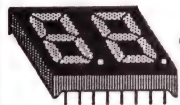
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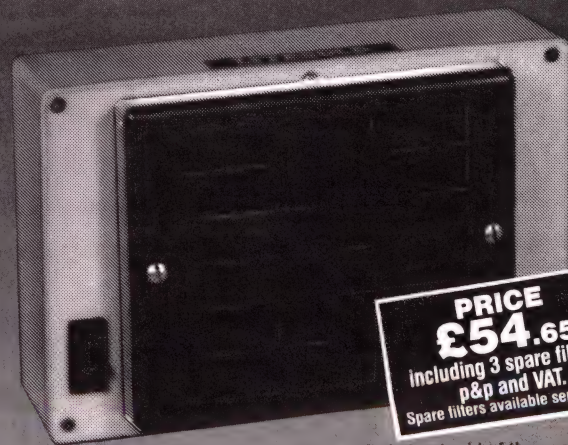
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- | | | |
|------------------------|------------------|-------|
| 1) Colliders Cope | should have been | _____ |
| 2) Casual Tea | should have been | _____ |
| 3) Cora Nation's Treat | should have been | _____ |
| 4) Stale Ucky | should have been | _____ |
| 5) Start Wreck | should have been | _____ |
| 6) Woe Gun | should have been | _____ |

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owners is what I meant to say, of course. Anyway, now you've filled in your answers you can choose any one of the gifts below!

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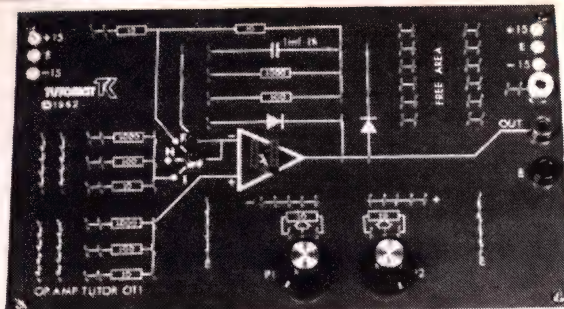
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- BT approved. ● Link up with Prestel, Telecom Gold, Mailbox. ● Contact bulletin boards and information services. ● Communicate with any computer anywhere. ● Send previously prepared messages. ● Receive messages—forget answer machines, use electronic mail! ● Use (via Telecom Gold) as an alternative to Fax and Telex. ● Built-in call charge calculator, text editing, message storage. ● Standard Centronics printer port for hard copy. ● RS232 capability for use as a modem for other computers. ● IBM keyboard emulator available. ● Modem can be configured, via Vistel's keyboard, for word length, start and stop bits, odd, even or no parity, V21 or V23 protocols, and so on. In other words, it will talk to anything! The ideal hacker's tool?

**Intended Price
£1280**
**FROM US ONLY
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While Stocks Last
**Tel: 0600 3715
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The Vistel was designed by TCS to be the ultimate in desk top communications for the new age of information technology. Many more people will be working from home, so it will send and receive messages and data, give access to the computer, receive (via Telecom Gold) telex and fax messages, and keep you generally in touch with what's going on.

Instant access to information will be increasingly important too. There already exist massive databases and information stores, if only you could tap into them. The Vistel will do just that.

The firm that made these beautiful machines ran out of money before they could start selling them and, sad to say, went into liquidation. We now have all the completed Vistels: absolutely brand new, boxed, with full 100 page operating manual. Made to sell at £1280, we ask only £198 + VAT from anyone quick enough to order before they're all gone.

GETTING STARTED

Installing your Vistel couldn't be easier—you just unplug your telephone, pop the Vistel's connector into the socket, plug your telephone into the back of the Vistel, push the Vistel's mains plug into the nearest outlet, and you're up and running.

Your Vistel will get you into all kinds of data bases, bulletin boards, mail services, news and information services, and goodness knows what else. Most of the services are yours for a small subscription charge, and some are free!

While you're waiting for the postman to deliver your Vistel, why not ask BT to send details of their Prestel and Telecom Gold services? Call them up on 0800 200700—it's a freephone number, so you won't even be charged for the call. The bump they send out includes info on Games City, Mailbox, music, current affairs, stock market and sports services, and lots more.

The bulletin boards and special interest groups are usually run by enthusiasts for free. Very professional some of them are, too. Try this: set the Vistel's modem to V23, 8-bit, no parity, one stop bit. Now dial 0772 735122. Once you hear the ringing tone, press the 'Kbd Modem' switch, which allows the Vistel to work as an interactive terminal. After a few minutes the log-on message will appear on the Vistel's screen, and you're in!

You've just contacted the Hobbit's Armpit bulletin board. While you're there you can call up the newsletter, find a brief history of the world, how the Egyptians learned to make bread without straw—all very silly, but what the hell? It's free! Or download bits of software, or whatever else may be on offer at the time you phone through.

Here are some more numbers you can try:

PRESTEL DEMO Obviously they're trying to get you to subscribe to the full service, so they let you poke around a little to see what's on offer. A good opportunity for hackers, maybe...

Tel: 01 South or 021 Midlands or 061 North or 041 Scotland followed by 618 1111. To log on, use ID 4444444444 ten 4s and password 4444. Modem setting: 7 bits, even parity, one stop bit.

PACKET BBS A free service run by the RSGB. Dial: 01 547 1479. Hit CR for response. Modem setting: 8 bits, no parity, 1 stop bit.

INDEX 3 A Swedish bulletin board for the adventurous, and for those with no worries about running up outrageous telephone bills. Dial: 010 46 42138 476.

HAWK'S CASTLE An interesting bulletin board which often has numbers for yet more bulletin boards. Who knows where you might end up? Dial 0344 411621.

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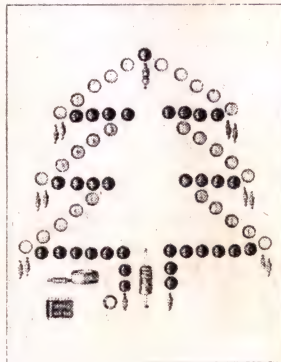
Signed.....

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An unrivalled kit comprising all the parts to build a superb "Picture PCB" of a Christmas tree, which, when connected to a power supply (or battery) of 12-14vdc, will flash alternately from red to green and back again at an adjustable rate. The other components on the PCB have been arranged to appear as parcels at the bottom of the tree, and resistors hang from the branches! Power consumption is around 100ma, so you could leave it in the rear window of your car and impress the neighbours! Or stick it on top of the real Christmas tree. With a total of 63 LED's, this is a real eyecatcher! Size 100 x 110mm.

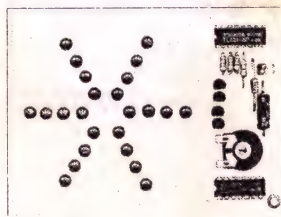
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STAR CHASER!

A superb 24 LED chaser display. The kit contains everything you need, including the PCB and easy to follow instructions to build the "Star chaser" which gives the impression of a circle of light spreading outwards from the centre. The kit is available with red or green LED's, both at the same price. A PP3 battery or 9v power supply is required. Size 100mm x 70mm.

COMPLETE KIT £7.50



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4007	23p	4028	41p	4066	34p	4058	142p	4538	44p
4008	48p	4029	44p	4068	23p	4510	53p	4539	62p
4011	23p	4033	126p	4069	23p	4511	53p	4541	53p
4012	23p	4035	28p	4070	23p	4512	53p	4543	80p
4013	28p	4038	106p	4071	23p	4514	115p	4553	221p
4014	42p	4040	55p	4072	23p	4515	115p	4554	354p
4015	41p	4042	40p	4073	23p	4516	62p	4556	60p
4016	28p	4043	54p	4075	23p	4518	41p	4560	195p
4017	44p	4044	54p	4076	50p	4520	44p	4561	221p
4018	41p	4046	50p	4077	23p	4522	80p	4566	283p
4020	48p	4047	41p	4078	28p	4526	64p	4582	203p
4021	48p	4049	32p	4081	23p	4527	71p	4584	37p
4022	49p	4050	32p	4093	28p	4528	67p	4585	53p
4023	23p	4051	41p	4094	50p	4529	71p		

LINEAR

CA3046	71p	LM3352	124p	MC3302	133p	TL072	57p
CA3080	85p	LM339	39p	MC3340	203p	TL074	74p
CA3130	142p	LM348	48p	NE555	28p	TL081	48p
CA3140	67p	LM358	39p	NE556	53p	TL082	62p
CA3240E	159p	LM380	142p	NE565	159p	TL084	74p
ICM7555	71p	LM381N	300p	NE566	159p	UA709C	62p
ICM7556	124p	LM382	248p	NE567	53p	UA741	28p
LF347	88p	LM386	124p	NE5532	97p	UA747	78p
LF351	48p	LM387	192p	NE5534	80p	UA748	45p
LF353	62p	LM393	39p	SAA1027	327p	ULN2003	71p
LF355	248p	LM710	80p	SL560C	268p	ULN2004	71p
LF356	103p	LM723	44p	SP8629	265p	ULN2803	115p
LM301A	36p	LM1458	39p	TBA120S	95p	XR2206CP	540p
LM308	88p	LM2917	300p	TBA810	103p	ZN414	142p
LM311	39p	LM3900	106p	TBA820M	71p	ZN416E	221p
LM317T	80p	LM3909	168p	TDA2030H	177p	ZN424E	124p
LM324	39p	LM3914	336p	TDA7000	220p	ZN427E	991p
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MICRO-PRESSURE CAR ALARM

This new type of alarm is triggered by a unique pressure sensing system. As any vehicle door is opened, air is drawn out, causing a minute drop in air pressure. A sensor detects this sudden pressure change and sets off the alarm.

This new sensing system and a sophisticated arrangement of electronic filters and timers provide features to match more expensive ultra-sonic systems.

- ★ 1 Micro-Pressure intruder detection.
- ★ 2 Operates on all doors and tailgate.
- ★ 3 No door switches needed.
- ★ 4 Automatically armed 1 minute after leaving vehicle.
- ★ 5 10 second entry delay with audible warning.
- ★ 6 Sounds horn intermittently for 1 minute.
- ★ 7 Easy fitting - only 3 wires to connect - no holes to drill.
- ★ 8 Compact design can be hidden below dashboard.
- ★ 9 All solid state Power MOSFET output - no relays.

MICRO-PRESSURE ALARM KIT £15.75
ASSEMBLED READY TO FIT £21.75

VOLT DROP CAR ALARM

This alternative alarm uses the popular voltage drop method of triggering. Based on the timers of the micro-pressure alarm it offers features 4 to 9 above but relies on the existing door switch operation for triggering.

VOLT DROP ALARM KIT £14.55
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Our unbeatable Extended CDI system retains the contacts for easy fitting. The contacts operate at low current whilst the 12v supply is converted to 370v for a super power spark with improved starting, performance and economy.

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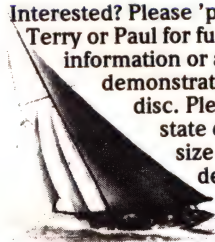
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These high value, high ripple current cans are made by BHC/LCR and are of excellent quality and value.

Code	Value	Voltage	Ripple	l x d	Mfr price
Z4343	2200µF	40V	2.7A	45 x 26	£2.12
Z4344	4700µF	63V	4.4A	56 x 36	£3.77
Z4345	10,000µF	40V	4.9A	56 x 41	£3.89
Z4346	15,000µF	25V	5.5A	56 x 41	£3.96

Prices:					
Z4343	60p	25+	£0.52	100+	£0.345
Z4344	£2.00	25+	£1.84	100+	£1.49
Z4345	£2.50	25+	£2.07	100+	£1.72
Z4346	£2.50	25+	£2.07	100+	£1.72

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Z914 Audio amp panel 95 x 65mm with TBA820 chip, gives 1W output with 9V supply. Switch and vol control. Just connect battery and speaker. Full details supplied.

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Z915 Stereo version of above 115 x 65mm, featuring 2 x TBA820M and dual volume control.

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SWITCH MODE POWER SUPPLIES

Over the years, we've had many different switch mode power supplies, but this latest unit is without doubt one of the finest we've ever seen!

Made by Astec, it is a totally enclosed steel cased unit measuring 175 x 136 x 65mm, which has incorporated in it a switched and fused IEC mains inlet.

Inside, the PCB is 160 x 80mm with output pins fitted on one end. A connector to these pins to extend the outputs to the exterior of the case is provided.

Specification:
Model Number: **BM41012**
Input: 115/230V, 50/60Hz
Outputs: +5V 3.75A
+12V 1.5A
-12V 0.4A

Total Wattage: 65W
Price: **£14.95**

We've also discovered a small quantity of an Aztec model offered previously. Regrettably we've had to increase the price, but they still represent outstanding value for money. Enclosed in a steel case 203 x 112 x 60mm is a PCB 197 x 106mm. Input/Outputs are via pins on the PCB

Specification:
Model Number: **AC9231**
Input: 115/230V, 50/60Hz
Outputs: +12V 2.5A
+5V 6A
12V 0.5A (+ or -)
5V 0.5A (+ or -)

Total Wattage: 50W
Price: **£17.95**

We still have good supplies of yet another Astec model. This one is partially cased, the overall size being 160 x 104 x 45mm. The PCB measures 160 x 100mm. Input & Outputs on flying leads, all colour coded. There is also an additional IEC socket to extend mains to another unit.

Specification:
Model Number: **AA12531**
Input: 115/230V, 50/60Hz
Outputs: +5V 5A
+12V 0.15A

Total Wattage: 50W
Price: **£6.95**

Also still available: An Astec 'bare board' model. The PCB is standard Eurocard size, 160 x 100mm. Inputs & Outputs are on right angled PCB pins. This is a very compact model offering excellent value for money.

Specification:
Model Number: **AC8151-01**
Input: 115/230V, 50/60Hz
Outputs: +5V 2.5A
+12V 2A
-12V 0.1A

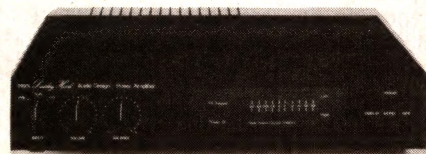
Total Wattage: 40W
Price: **£12.95**

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Telephone or write for your **FREE LISTS** giving full details of all our Kits, components and special offers. Featured this month is the:

AUDIO DESIGN 80 WATT POWER AMPLIFIER



This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hifi system. This kit is your way to get EK performance for a few tenths of the cost!

Featured on the front cover of 'Electronics Today International' this complete stereo power amplifier offers World Class performance allied to the famous **HART** quality and ease of construction. John Linsley Hood's comments on seeing a complete unit were enthusiastic: -

"The external view is that of a thoroughly professional piece of audio gear, neat, elegant and functional. This impression is greatly reinforced by the internal appearance, which is redolent of quality, both in components and in layout."

Each power amplifier channel has its own advanced double sided PCB and no less than four power mosfets, directly mounted on the board for consistent predictable performance. The sophisticated power supply features no less than six separate voltage rails, all fully stabilised, and the complete unit, using a toroidal transformer, is contained within a heavy gauge aluminium chassis/heatsink

fitted with IEC mains input and output sockets. To make assembly very easy all the wiring is even pre-terminated, ready for instant use:

The standard amplifier comes with the option of a stereo LED power meter and a versatile passive front end giving switched inputs, and ALPS precision, low-noise volume and balance controls. All inputs are taken to gold plated Phono sockets and outputs to heavy duty 30 amp binding posts. These are also available gold plated as an optional extra.

Another new option is the relay switched front end stage which even gives a tape input and output facility. This means that for use with tuners, tape and CD players, or indeed any other 'flat' inputs the power amplifier may be used on its own, without the need for any external signal handling stages. For your special system requirements our 'Slave' and 'monobloc' versions without the passive input stage and power meter are also available.

All amplifiers fit within our standard 420 x 260 x 75mm case to match our 400 Series Tuner range. The case and front plate are finished in textured matt black with white lettering and all parts are precision jig-punched for accuracy.

K1100 STANDARD Amplifier kit.
Total cost of all parts is £503.56

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If Bargraph Power Meter not required. Deduct £32.81

If Relay Input System required. Add £39.43

K1100G Option with Gold plated speaker terminals. Add £4.40

K1100S SLAVE Amplifier Kit

Total cost of all parts is £382.85

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K1100M MONOBLOC Amplifier kit. Total cost of all parts is £297.65

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All **HART** kits are designed to the very highest standards for easy home construction, and can be built by anyone with reasonable manual ability. If you are still not convinced how easy it is to build it yourself with a **HART** kit you can order the Instruction Manual to read for yourself and we will refund the cost when you buy your kit!

1100CM Construction Manual. 20+ pages of step by step assembly instructions, circuit diagrams and full parts identification list. £5.50

RLH11 Reprints of the latest 1989 articles £1.80

Our **FREE LIST** has further details of this kit as well as our range of super quality tuners, ALPS precision pots and tape recorder circuits. Send for your copy.

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Do your tapes lack treble? A worn head could be the problem. Fitting one of our replacement heads could restore performance to better than new! Standard inductances and mountings make fitting easy on nearly all machines and our TC1 Test Cassette helps you set the azimuth spot on. As we are the actual importers you get prime parts at lower prices, compare our prices with other suppliers and see! All our heads are suitable for use with any Dolby system and are normally available ex stock. We also stock a wide range of special heads for home construction and industrial users.

HS16 Sendust Alloy Stereo Head. high quality head with excellent frequency response and hyperbolic face for good tape contact. £17.86

HC40 NEW RANGE High Beta Permalloy Stereo Head. Modern space saver design gives excellent high-frequency response with easy fitting and lower cost. Suitable for chrome, metal and ferric tapes, truly a universal replacement head, with ample quality for hifi decks and cheap enough for car players! £2.65

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HRP373 Downstream Monitor Stereo Combination Head. £44.39

HQ551 4-Track Record & Play Permalloy Head for auto-reverse car players or quadraphonic recording. £16.79

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Please add part cost of carriage and insurance as follows:

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1000p to 8200p - 3p, 0.01 to 0.68, 4p, 0.1, 5p, 0.12, 0.15, 0.22, 0.47, 0.68, 1.0, 1.2p	
Submin ceramic plate capacitors 100V wkg vertical mountings. E12 series	
2% 1.8pf to 47pf - 3p, 2% 56pf to 330pf - 4p, 10% 390p - 4700p	4p
Disc/plate ceramics 50V E12 series 1P to 1000P, E6 Series 150CP to 47000P	2p
Polystyrene capacitors 63V working E12 series long axial wires	
10pf to 820pf - 3p, 1000pf to 10,000pf - 4p, 12,000pf	5p
741 Op Amp - 20p, 555 Timer - 22p, 4017	22p
cmos 4001 - 20p, 4011 - 22p, 4013	40p
ALUMINIUM ELECTROLYTICS (Mfds/Volts)	
1/50, 2.2/50, 4.7/50, 10/25, 10/50	5p
22/16, 22/25, 22/50, 47/16, 47/25, 47/50	6p
100/16, 100/25, 100/50, 100/100, 100/100	14p
220/16, 220/25, 220/50, 470/16, 470/25	11p
1000/25, 25p; 1000/35, 2200/25, 35p; 4700/25	70p
Submin. tantalum bead electrolytics (Mfds/Volts)	
0.1/35, 0.22/35, 0.47/35, 1.0/35, 3.3/16, 4.7/16	14p
2.2/35, 4.7/25, 4.7/35, 6.8/16, 15p; 10/16, 22/6	20p
33/10, 47/6, 22/16, 30p; 47/10, 35p; 47/16, 60p; 47/35	80p
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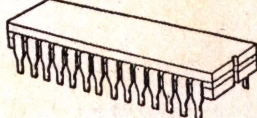
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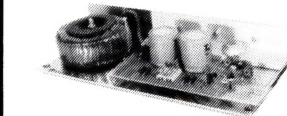
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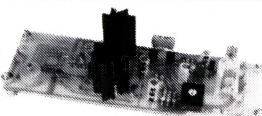
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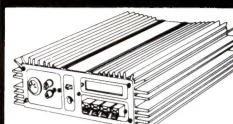
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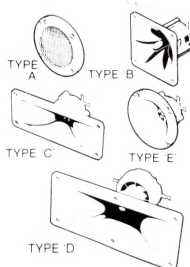
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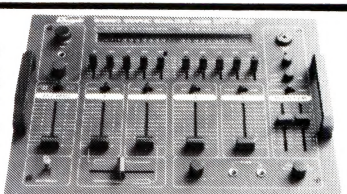
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